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# FIRST ANNUAL REPORT

ON THE

# GEOLOGICAL SURVEY

OF THE

# STATE OF WISCONSIN.

BY EDWARD DANIELS.

MADISON:
DAVID ATWOOD, PRINTER.
1854

# GEOLOGICAL REPORT.

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*To his Excellency*, LEONARD J. FARWELL,
*Governor of Wisconsin:*

I herewith transmit to you the first annual Report upon the Geology of Wisconsin, made in accordance with an act of the Legislature, authorizing a geological survey of this State, and with the execution of which, I have been entrusted by your Excellency.

The provisions of the bill, under which I act, require that the district known as the "Lead Mines" should be surveyed before commencing any other portion of the State. I have therefore confined myself to this district in conducting the survey, and shall continue to do so until I have completed its exploration. The great intrinsic importance of the lead mines, and the general misapprehension which exists in regard to them, both at home and abroad, demand that some authentic and reliable information of their character and resources should be laid before the public. In this report are embodied such facts and conclusions, bearing upon this point, as the brief researches of the past season have enabled me to furnish. They are entirely practical in their character, and confined mainly to the economical geology of the district. In all the investigations made, my inquiries have been directed to one object, viz: To ascertain what useful mineral substances existed in the district; their mode of occurrence; and the best method of rendering them available in the practical uses of life. Incidenthe sombre depths of primeval forests; and castellated cliffs, rising hundreds of feet, with beetling crags which a Titan might have piled for his fortress. Such are the location and prominent physical characteristics of the country occupied by the lead mines of Wisconsin.

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# CHAPTER II.

## GEOLOGY OF THE LEAD MINES.

Under this head I propose briefly to describe the prevailing rocks, which underlie the mining district, so far as we have been able to ascertain them. The rocks of the globe are divided by geologists into two great classes, the stratified and unstratified. Those which are found to have a regular arrangement in parallel layers are called stratified, while those which have no such structure, but are irregular and massive in form are called unstratified. The rocks of this district all belong to the former class. They are arranged in regular parallel layers of varying thickness, having generally a position slightly inclined or horizontal. They consist chiefly of limestone and sandstone, with occasional beds of shale and clay. They are arranged one above another in an invariable order, so that they always occupy the same relative position in a vertical scale. The accompanying sections exhibit the order of succession, position, and relative thickness of these rocks, more clearly than any verbal description.

Section No. 1, exhibits the succession of rocks which would be encountered in sinking a shaft from the highest points of the surface to the lowest rocks, which have yet been brought within the reach of our observation. In descending from the surface we shall encounter the following beds in the order here named, as shown in the section.

1st. Clay, from ten, to sixty feet thick.

2d Thin bedded hard white limestone, three hundred feet.

3d. Shale, of blue or brown color.

4th. Thick bedded gray limestone, two hundred feet.

5th. Thin bedded blue or brown limestone, with layers of shale, fifty feet.

6th. Yellowish thick bedded limestone twenty five feet.

7th. Sandstone of various colors, generally light gray or red, forty feet.

8th. Limestone with intercalations of sandstone.

The stratification of these beds is conformable, or very nearly so. The whole series have a south-easterly dip, at the rate of about ten feet to the mile, as seen in section No. 2. These beds I shall now notice more particularly in a descending order, beginning with

## No. 1.—Surface Clay.

The thickness of the superficial clay is exceedingly variable, but outside of the vallies it is rarely less than 8 feet. It attains its maximum thickness in the southwestern portion of the district. Near the Sinsinawa Mound, in Jamestown, it assumes the form of pipe clay, and presents several distinct beds, with an aggregate thickness of 60 feet. From this point heavy beds stretch northward for nearly forty miles, differing however from that in Jamestown. At the latter place, and also at Potosi, I found a small fresh water shell, (*Limnea galbana*, of Say,) in great abundance about twenty feet below the surface. So numerous were they, that hundreds were contained in every shovel full of the clay, and so tender that they rapidly decomposed when exposed at the surface. Another class of fossils of great interest are peculiar to these clay beds. I allude to the gigantic bones which have been discovered at Fairplay and Potosi. Those found at Fairplay are now in the possession of J. Potts, Esq., of Galena. They belong to an elephant and mastodon. They are in a very fair state of preservation, and will be more fully described hereafter. Two discoveries of this character have been made at Potosi. Of one I could obtain only a verbal account, as the specimens had all been destroyed or carried away. In the other case I succeeded, through the kindness of Mr. Hull, upon whose ground the bones were discovered, in obtaining a few small pieces. Among these was a fragment of a tooth, which proved the owner of the huge bones to have been an elephant. The bones were so far decayed that they crumbled to dust as soon as the dirt was removed from them; otherwise the entire skeleton of the elephant might have been secured. I may remark in this connection, that I have received from LUTHER IRISH, Esq., of Sextonville, Richland county, a very

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The origin of this surface clay seems to have been in great measure owing to the decomposition of the rocks, which once occupied its place. This is proved from the frequent occurrence in it of flints and lead ore, which have survived the waste of the rocks in which they were once imbedded. The peculiar character of the clays in the western part of the district, however, together with the fossils which they contain, indicate that a large fresh water lake must have once existed there. A remarkable fact in the superficial deposits of this region is the entire absence of the drift so abundantly represented over the north-west generally, by boulders, gravel, sands, and clay. So far as my observation extends, not a single boulder or gravel stone can be found over the whole district. The surface material bears no evidence of distant origin, and unless some of the clays shall be proven diluvial we have here no traces of transported drift. Whatever then may have been the agency which dispersed the huge masses of rock, fragments of native copper, beds of sand and gravel, so lavishly over the surrounding country, we know, that by some peculiarity of position the lead region was above its reach. Widely removed as this circumstance may seem from practical matters, it has nevertheless a most important bearing upon the economical value of the district to which it relates. For had it been otherwise the whole surface would have been covered with loose deposits, often of great thickness, burying all indications of the presence of lead veins, rendering discovery exceedingly doubtful, and profitable mining a practical impossibility. The precise boundary of the district thus destitute of drift, is not yet ascertained.

### NUMBER 2.

Next in the order of geological position are the beds of limestone forming the highest points of the surface, capping the mounds and table-lands. These have been called the "coraline beds of the cliff limestone," by Mr. OWEN, on account of the great abundance of fossil corals which they contain. The greatest thickness of this rock is about 400 feet. Its strata vary much in thickness, but are usually thin. Its color is light gray, texture crystaline, and occasional layers of flint are disseminated through it, aggregated into nodules. It has been quarried at Sinsinewa and Platte Mounds, and furnishes an excellent building material. The fossils are very abundant and well preserved, and usually silicious. The most common forms are the beautiful chain coral, (*catenipora*,) the *pentamerus oblongus*, popularly known as a "petrified nut;" and the fossil coral, known as "petrified honey comb." This formation is now represented here by a few outlayers, capping the mounds, and extending a thin skirt over the surrounding table lands.

This slight horizontal development, as compared with its great thickness, has undoubtedly been caused by the wearing away of these beds from a large portion of the surface which they once occupied.

The amount of erosion that the surface of the district has suffered, is immense, and may be seen by reference to section No. 2. Here the dotted lines, extending from the top of the Blue Mound to Sinsinewa, indicate the extent of this formation before it had been acted upon by the agencies of waste. The whole space between these mounds, and below this line, has been worn away by the action of atmospheric agents and running water. The mounds are merely remnants or outlayers. Their existence may be assigned to two causes. First, greater hardness of texture than the surrounding rocks, enabling them longer to resist the destructive action of the elements; Second, an original elevation above the general level, making them the centers of drainage from which all the streams radiate. This would relieve them, in some measure, from the erosion of running water, by which the adjacent levels, less favorably located in this particular, would be worn away around them. The Blue Mounds are capped by a mass of stratified hornstone or flint, nearly 300 feet thick. It contains fossils resembling those of the coraline beds. The occurrence of such a mass of silicious matter in this form, is a very striking phenomenon. That it must have originated under similar circumstances to the limestones with which it is associated, is proved by the fact that it contains the same fossils, but it is evident that some local agency must have been active in forming a deposit so extensive and anomalous at this point, while it occurs only in small quantities elsewhere. The abundance of fossil corals found upon these mounds remind us of the scattered fragments about a modern coral reef. They prove that these mounds were once the sites of similar operations, where the little coral animals reared their stony architecture beneath an ocean whose waters covered the whole land. Under this ocean the beds of limestone which I am describing, were slowly formed, partly by the deposition of lime, held in solution, and partly by the slow growth of corals and shells, whose curious and beautiful forms they contain in such abundance.

### NUMBER 3.

Underneath the coraline beds, we find a shale bed. It is most largely developed in the southwest portion of the district, and gradually thins out towards the north and east. At Fairplay it attains a thickness of about 12 feet. Its general texture is soft and crumbling. Its color is blue, green, and sometimes brown or yellow. The upper portion of the bed contains circular nodules resembling clay stones, and consisting mainly of iron oxide. Calcareous nodules of a lenticular form are also found cemented together in such quantity as to form nearly the whole bulk of some strata. This part of the formation is generally destitute of fossils. The lower portions, however, are wonderfully rich in petrifactions, preserved in the highest perfection. The entire rock is often a mass of fossils, with barely enough of some cement to hold them together. These fossils are mainly shells. Among them we find abundantly, *pleurotomaria*, *endoceras*, *modilopsis*, *nuculaformis*, *didopherous-planulatus*, *nucula-poststriata*, *lingula*, with a few *trilobites* and other fossils unknown.

It is a singular fact, that all these fossils are exceedingly minute as compared with those of similar types, found in the rocks below. The huge chambered shells of the lower limestones, measuring often six feet in length and two feet in diameter, are here represented by forms, rarely exceeding four inches in length, and one inch in diameter. The *nucula* of the gray limestone is often two inches in length, while that of the shale is only one-third of an inch long. A similar diminution seems to have affected every form of life; constituting as it were, a fossil Lilliput, analagous to what Hugh Miller has described as the "age of dwarfs," among the fishes of the old red sandstone.

This deposit extends across the Mississippi into Iowa, and south into Illinois. It offers to the naturalist a new field of investigation, replete with interest and instruction. In this brief notice I can barely call attention to the fact of its existence, but hope at some future time to present a fuller account of it and its wonderful fossils. I have called it for the present the "nucula shale," from the great numbers of this fossil which it contains.

### Number 4.

Next, succeeds the gray limestone. This is the prevailing surface rock of the mines. Its upper beds consist of a very hard whitish limestone, with few fossils, the most common of which is the *lingula Iowensis* of Mr. Owen. The black oxide of manganese often covers the surface of the layers with beautiful markings, resembling the delicate branchings of the mosses. These layers form what is called the cap rock to the perpendicular veins of the western portion of the mines. The succeeding layers are of a bluish gray color, of a more open texture, and when examined closely are found to consist of minute crystals of carbonate of lime. This rock often contains sulphuret of iron, by the decomposition of which it assumes a yellowish cast in weathering, and yields as it crumbles, those loose beds resembling sand, and so often mistaken for that substance in the mines. A glass of moderate power detects the mistake, and shows the grains of which it consists to be angular crystals of lime.

The fissures which in the upper layers are represented by mere seams, here expand in width often several hundreds of feet, forming the great caves, for which the region bordering the Mississippi is especially noted. These fissures are the great repositories of lead ore. They are usually filled with clay and loose materials, which have washed in from the surface. The layers of this rock are from one to four feet thick. Nodules of flint arranged in parallel layers, are of frequent occurrence.

The lowest beds of the gray limestone are disposed in thin layers of a chocolate or reddish-brown color, known among miners as the "brown rock." This rock contains great quantities of calc. spar or "tiff." The entire rock in some cases seems to have been metamorphosed, being converted into "tiff," with a residuum of earthy matter. This metamorphic action seems to have occurred only in the vicinity of fissures.

The characteristic fossil is a circular coral, (*coscinopora sulcata,*) popularly called the sun-flower coral, and sometimes taken to be a petrified wasp's nest.

### Number 5.

The blue limestone lies immediately below that last described.

It consists of soft shales interstratified with very compact limestone. It is generally thin bedded, of a blue or brown color when recently fractured, and intersected with numerous joints. It is remarkable for the frequent alternation of its strata; the vertical thickness of a few feet often presenting layers widely differing from each other in texture.

The fossils of the blue limestone are very abundant and well preserved. They are mainly shells, corals and crustacea, with frequent impressions of fucoids, or sea-weeds, ramifying over the surface of its layers.

The lower layers are thicker and less fossiliferous. They have a smooth conchoidal fracture, a fine, compact texture, and take a very good polish; forming an excellent building stone. The beautiful edifice recenly erected at Platteville for a Seminary, is mostly constructed from this stone, obtained from McCord's quarry. No flints are found in the blue limestone.—This rock is often intersected by veins of calc. spar, and cavities occur lined with beautiful crystals of the same substance.—This rock covers but a small portion of the surface, having only a narrow out-crop along the valleys of the streams. Its thickness varies from 30 to 100 feet. It is thickest in the north-west, near the mouth of the Wisconsin, and thins out toward the south and east. It is undoubtedly the equivalent of the blue limestone so abundantly developed at Cincinnati, Ohio; and identical with the Trenton limestone of the New York geologists.

## Number 6.

Below the blue limestone, we find a rock differing widely from it in texture and general character. Its ordinary color, where weathered, is light yellow or buff. It is intersected by large fissures, resembling those of the gray limestone. Its fossils are generally casts. It weathers with a smooth, even surface. It is known as the "quarry rock" at Mineral Point, where it has been used in the erection of several buildings. Its usual thickness is about 25 feet, but it thickens gradually towards the east. Believing it to be identical with the rock represented by Mr. Locke, in a section at Prairie du Chien, and called by him the "buff-colored limestone," I have chosen to retain that name.

### NUMBER 7.

Below the buff-colored limestone, sets in a bed of sandstone, from 40 to 100 feet thick. It consists of coarse grains of quartzose sand, cemented together usually with iron and carbonate of lime. Its prevailing color is red, but sometimes it is gray or white; darker and lighter bands frequently occur. The lines of stratification are very indistinct, and sometimes no traces of them appear. It is divided by vertical fissures into immense blocks. Its texture varies from the softness of incoherent sand to the hardness of the most solid rock. This sandstone is thickest in the north, and thins out towards the south and west. It is exposed in the valleys of all the principal streams. At Mineral Point, on the Peckatonica and Blue river near Centerville, and at Pine Bluff, between Mineral Point and Madison, fine out-crops of this formation may be seen.

### NUMBER 8.

Next to this sandstone succeeds another limestone—the lower magnesian limestone of Mr. Owen. This rock is exposed only the deepest valleys of the lead district. Its strata vary much both in texture and thickness. In its upper part, intercalations of sandstone occur. The layers are thin, and of a light gray color. Flint, often in angular fragments, sometimes in layers, and occasionally in the form of a silicious oolite, abounds. In some cases a concretionary structure was observed. This was noticed particularly in an exposure of this rock in the valley of the Mississippi, on section 3, town 4, range 6, about two miles above Way's Landing. The concretions are often three feet in diameter, and consist of thin concentric layers of a silicio-calcareous matter. They have been mistaken for "petrified logs." These beds exhibit this concretionary tendency nearly everywhere; though in some cases it is shown only by a waved lamination.

The lower beds are thicker and more massive, much resembling the gray limestone. Small cavities, lined with minute crystals of quartz, called druses, are of frequent occurrence, and are peculiar to this formation. Fissures and joints intersect it. Fossils are rare, and imperfect casts only are found. The precise thickness of the lower magnesian limestone is not known. An exposure of 180 feet is seen near the mouth of the Wisconsin river; and a much greater thickness may be measured north of the Blue Mounds.

I have thus given a brief description of the geology of the lead region. The rocks, whose prominent characters and stratigraphical relations have been described, are the only ones exposed on any part of its surface. They are of great horizontal extent, and can be traced over the whole district, and some of them hundreds of miles beyond; but they everywhere occupy the same order of superposition represented in the sections given. By an examination of these sections, and a careful observation of the out-crops or exposures of the rocks, at different points, almost any person may learn to recognize the various beds of rock wherever they occur. To a practical miner such knowledge is of the highest importance, and a valuable acquisition to every individual. I propose now to treat of the nature and distribution of those deposits of lead ore which have conferred upon these rocks their chief economical importance.

# CHAPTER III.

## THE LEAD VEINS OF WISCONSIN.

In determining the value of a metalliferous district, the first point to be settled is the mode in which the ores occur. Deposits of metallic ores are divided into two classes: First, those which occur in beds, bunches or veins of limited extent, usually called cotemporaneous deposits. Second, the veins which are defined to be "the mineral contents of fissures having indefinite length and depth." The former are local and irregular, with no constancy of direction, and never extend from one rock to another. The latter, on the contrary, extend vertically to great but unknown depths, and traversing every variety of strata. They may often be traced for many miles in a horizontal direction, pursuing the same general course throughout, and retaining their productiveness, subject only to transient interruptions. They are enclosed between walls of rock, separated from their contained substances by a distinct line of demarkation. The first class of deposits often give promise of a large yield, but fail when pursued for a length of time.—Millions of dollars have been wasted in prosecuting mining operations upon such deposits which seemed to give evidence of exhaustless stores of ore. The experience of the past has taught the necessity of great care in the selection of mining ground; and while it has proved the danger of adventures in those isolated and limited deposits, however rich at first, it has equally established the safety of liberal investments in the exploration of true metallic veins. All mines of the globe, distinguished of permanent value, belong to this latter class. To this class also may be referred most of the deposits of ore in the lead district of Wisconsin. They generally present the characters of true veins, and are therefore to be treated and relied upon as such. This will be evident, if we examine the general phenomena which they present.

### BEARING OF THE LEAD MINES.

The most general direction of the productive veins is east and west. The variation is usually from three to twenty degrees south of east—sometimes, however, it is north of east. Local variations often occur in the general bearing of the lode, but in most cases, if pursued, it will be found to resume its original course. An average of 123 observations upon lodes having an east and west direction, gives a mean variation of eleven degrees from the meridian line.

Another system of veins of less frequent occurrence are termed norths and souths. These vary from true north and south, so that the mean of 40 observations is 14 degrees. In many cases these have a direction nearly N. N. E. Still another class are called quarterings. They intersect the easts and wests at an angle of about 45 degrees; and are often known as "ten o'clock ranges." Besides these, there are strings and branches apparently flying off from the main ranges, and having every conceivable direction.—In a few instances, productive veins (probably by a succession of throws) assume a curved or crescent form, and are hence called "horse-shoe ranges." The easts and wests have probably yielded nine-tenths of all the ore raised in the district, and must be regarded as the characteristic or principal veins.

### HORIZONTAL EXTENT OF VEINS.

Many of these veins are of great length. Several of them have been traced three or four miles, pursuing their general course with such constancy that, when once struck, the compass may be used to discover their location at a great distance. The "Heath-Cock range," in the town of Lindon has been worked for nearly a mile continuously, and its extent for three miles, ascertained qy occasional shafts, which have been sunk upon it. The "Long Range," at Potosi, and the "Great Blackleg" in town 1, range 3 east, have each been worked a mile in length. The breadth of the veins varies from a few inches to 50 feet or more.

## VERTICAL EXTENT OF THE VEINS.

The depth to which the lead veins penetrate is altogether the most important feature connected with them in a practical point of view. For obvious reasons, it is also the most difficult to be ascertained—as it can be known only by following them into the profound depths of the earth. The deepest shafts yet sunk in the lead mines have penetrated only to the depth of 175 feet. Few even reach 100 feet, and most of the shafts range from 10 to 60 feet. Shallow as these workings are, they have nevertheless revealed many important facts, tending strongly to establish the continuity of the veins to much greater depths. Every practical miner or owner of mineral lands is deeply interested in having this question answered, viz: Do the lead veins continue downwards through the succeeding beds of rock, and carry in their lower portions sufficient ore to justify the increased expense of exploration? To answer this question, so far as could be done, has been made a leading object in the work of the past season. The gray limestone (No. 4, of the sec.) has already been mentioned as the principal surface rock of the lead district. This is the great lead bearing rock of the mines. It has been supposed by many, that the surface rock always carried the ore, and the opinion has been strengthened by the fact that when the veins are followed to the blue limestone below, they uniformaly dwindle and cease to be of workable value. Discoveries of working veins were occasionally reported to me as having been made in the blue limestone, but upon examination I have found them to be located in the lower beds of the gray limestone, which from their bluish cast, are often mistaken for that rock. Mr. OWEN also observed this interruption of the veins at the junction of the blue limestone with the gray, and remarks 'that no discoveries of any value have been made below the blue limestone." It is a general law of metallic veins that they are affected by the character of the rock through which they pass. If they have been very productive in one rock, on passing into another they usually become unproductive, or of no workable value. Mr. **Westgrath Foster** in his treatise upon the British Strata, mentions numerous instances of these interuptions. In the mines of Cornwall the veins in descending are sometimes cut off at a change of strata, and after remaining barren for hundreds of feet, again resume their productiveness. In such cases the veins is often followed for great distances, through the barren ground. The practical miner looking with confidence to a resumption of its productiveness, when a favorable change of rock is encountered, and the result generally proves the adventure to be judicious.

By all analogy, if the deposites of ore in our lead district are true veins, traversing rocks similarly various and cut off in the same way, we ought to expect a renewal of their productiveness. That such is really the fact, I hope to be able to prove by the results of long continued and careful observation. The veins cut off by the blue limestone, resume again in the buff-colored rock, (No. 6,) as might be expected according to the law just mentioned.—Such had long been my conjecture, as the ore in the descending veins generally continued strong until at, or just below the point of junction of the grav and blue limestone, where it suddenly dwindled or became dispersed in small cubes through the adjacent rock. The deposites of ore in this lower lead bearing rock, have been worked in a few localities only. At Mineral Point, Dodgeville, Blue Mounds and some other places, these deposites have been reached. At these points, owing to the dip of the rocks, and the wearing away of overlying beds, the buff-colored limestone is found near the surface, and hence easily accessible for mining purposes. Deposites in this rock are known as the "glass rock openings." The glass rock consists of the lower layers of the blue limestone, and is the cap-rock of the openings below. The miners seem in no case to have been conscious of their true geological position, in working these openings. This has been owing in some measure, to the fact, that in the vicinity of veins the rocks are often so changed, as nearly to obliterate their usual characters. In such cases very careful observation, and some knowledge of the general geology is requisite to intelligent exploration. The buff-colored limestone everywhere underlies the lead district, its depth varying with the altitude as shown in Sec. No. 2. From the erroneous impression that no ore exists beneath the blue limestone, the veins have generally been abandoned when that rock was known to be reached. Hence the lower openings have been discovered only when the rock approached the surface.

The richness of these openings, so far as they have been worked, justifies the conclusion that they will be found equally productive with those of the gray limestone.

The veins which have thus resumed their productiveness, are again cut off by the bed of sandstone, (No. 7.) Not the slightest trace of lead, zinc, or copper has ever been found in this rock, and so extensively is it exposed at the surface, that were it metalliferous, the fact could hardly have escaped observation. In the succeeding rock we might reasonably expect a favorable change. It is the lower magnesian limestone (No. 8,) Its texture is well adapted to the reception of ores, and its position, (being nearer the igneous rocks) is a circumstance favorable to productiveness. From these facts, and from the discovery of small quantities of ore in this rock at its out-crop, Mr. OWEN conjectured that the lower magnesian limestone would be found to contain lead ore in workable quantities. During the past season special attention has been directed to that formation, and discoveries have been made which strengthen that conjecture into certainty. The depth at which this rock lies over most of the region where the lead producing forces are known to have operated, render the investigation exceedingly difficult. In the northern portion of the district, along the Mississippi, Wisconsin and their tributaries, the lower magnesian rock has an extensive exposure. Along this exposure, numerous occurrences of lead in small quantities have been observed, and in one instance a very important discovery of ore has been made. This is located upon sec. 32, town 7, range 1 east. A branch of Blue River has here worn through the upper rocks and left a terrace of this limestone, rising about 20 feet above the bottom of the valley. During the past season float ore was discovered in the valley, which was traced to this terrace of rock; shafts were sunk, and the existence of heavy bodies of ore was proved. The ore is found in large masses, sometimes weighing 400 or 500 pounds. It is generally in openings surrounded by clay, but is sometimes scattered in crystals among the flints which abound there. The locality is near Franklin and Centerville, where heavy lodes have been worked in the gray limestone. Some ten or twelve miners were at work at this spot when I visited it. Nearly 40 shafts had been sunk, and ore discovered in most of them. Probably 200,000 pounds of ore have been raised from these diggings during the season. The ground is very favorably located for proving the veins to any extent, and it is to be hoped that a mine will be opened here on a scale sufficiently extensive to secure this result.

After these discoveries I can hardly regard it a matter of doubt that the veins continue downward into the lower magnesian limestone. and may be profitably worked in that rock. The addition to the lead bearing ground of the buff colored and lower magnesian limestones is one of incalcuable value, and one which if properly understood and appreciated will give a new impetus to the mining interest of the lead region. Even where these rocks are at the greatest distance from the surface, their depth is slight as compared with that to which mines are worked with profit in other countries. I know of no reason why similar results may not be expected here.

Having thus endeavored to state the evidence bearing upon the vertical extent of the lead veins, to greater depths than have yet been worked, I will now mention some of the leading features by which they are characterized.

## Grouping of the Veins.

A vein is very rarely alone, but is usually associated with several others. Among these one is more productive than the rest, and is designated the " champeon lode. " On either side of this, smaller veins are grouped like subordinates around their chieftain. This group is known as a " gangue " of veins. Several of these gangues are generally found near each other, and form together what is called the " body of mineral. " This assemblage of veins is bounded on every side by spaces which are apparently barren. In passing over the lead region one will notice that the mining operations are all concentrated at a few points. Between these stretch broad expanses, broken only here and there by a solitary prospect-hole. It is important to know whether these spaces are really barren ground, or are only waiting the hand of enterprise to develope their mineral wealth. It is most in accordance with the past history of mining and the known laws which govern the distribution of metallic ores, to suppose that they are collected into groups as they appear to be, and not equally dispersed over the whole district. It is by no means probable, however, that all the spaces apparantly barren are really so. On the contrary we may reasonably expect that rich discoveries will yet be made upon these unexplored grounds. Several experienced miners remarked to me that the bodies of mineral seem to have a north-easterly direction; or, as one of them expressed it, " seemed to throw around towards the north-east. " Dr. Percival, the distinguished scholar and geologist whom I had the pleasure of meeting in the mines, remarked a similarity in their shape to the crescent form of the trap ranges, which he had observed while conducting the geological survey of Connecticut. In the disposition of the individual members of the gangue of veins, we observe a very regular alternation, each being placed at nearly the same distance from every other. The gangues are also about the same distance apart. We thus have a serial order in the arrangement of these veins, giving us first, the individual vein; second, the gangues into which the veins are combined, at a parallel equi-distance; third, the group including these gangues connected by their cross courses into a great net-work of ore, called "the body of mineral." The relation of these veins to each other is a matter of great interest, both in a practical and scientific point of view, and every pains should be taken to collect facts bearing upon it.

### POSITION OF THE LEAD VEINS.

The veins of this district present almost every variety of position, but they may be included in two classes, viz:—the perpendicular and horizontal. The perpendicular vein consists of a fissure, having a direction vertical or slightly inclined. It pursues its way downward by a succession of throws, which give it a zig-zag course very similar to its mode of horizontal extension. Its breadth varies from a mere seam to a hundred feet. Sometimes it is entirely obliterated for a short distance, being crossed by a tabular mass of rock, called the "cap rock." Upon sinking through this, an expansion of the fissure occurs, called an "opening." These openings are usually filled with clay, loose rocks, and massive ore. Occasionally, however, they are empty, or partially so, forming caves, whose walls are hung with stalactites. The best examples of vertical veins occur in the south-west portion of the district. At Fairplay and across the Mississippi, at Du Buque, these veins have yielded prodigious quantities of ore. The caves here are noted for the rare beauty of their spars. In some instances they are partly under water, forming subterranean lakes, into which boats have been lowered and voyages taken a hundred feet below the surface. In these caves the ore is generally found attached to the roof and sides, or scattered through the clay which covers the floor. It is rare to find a continuous sheet of ore in these veins. After sinking through the opening the walls come together again, or the veins becomes "pinched," as the miners express it, and yields little or no ore. The miner, however, still continues his work, knowing by past experience that another opening will soon succeed to repay his toil. In many of these caves the ore occurs partially imbedded in the wall rock on either side in small flat openings or pockets, forming isolated masses. These masses are sometimes of great size, weighing occasionally from 50,000 to 100,000 pounds. Good examples of these broken sheets may be found at Benton, Potosi, Hazel Green and Shullsburgh.

The second class of veins consists of flat sheets, continuous for great distances, and running between the strata, parallel to their plane of stratification. Occasionally, however, they incline downwards or upwards for a few feet, but their dip is very irregular. These flat sheets have been very productive in many localities.—Good examples occur at Mineral Point, Dodgeville, Linden, Messersmith's and Blue Mounds. They are usually connected both above and below with vertical veins. Both these classes seem to have a special geological position. Thus the perpendicular veins, with large openings and caves, are nearly confined to the gray limestone. The middle and lower beds carry flat openings and flat sheets, while flat sheets alone are found in the buff-colored limestone.

"Chunk mineral," "float mineral" and "patch mineral" are broken sheets which have been left by the decomposition of the rock, which once inclosed them, and are now found in the loose material of the surface.

## VEIN STONES.

In the perpendicular veins, the ore is usually unaccompanied by any of those substances known as vein-stones. The flat sheets, however, are usually associated with some mineral substance, which is the matrix of ore. The most common of these substances are tiff, black jack, dry bone, iron pyrites, ochre, barytes. These accompany the lode, either singly or combined in varying quantities; sometimes filling the entire vein, even, and taking the place of the ore, and at other times entirely absent or very slightly developed. The arrangement of these substances is often in parallel layers, called combs. In such cases the succession is quite irregular. The ore is sometimes upon one side of the vein, and the vein-stone upon the other, or it runs between the layers of its matrix, dividing often into several branches. In other cases the ore and vein-stone are mingled in one mass, requiring the process of roasting and stamping to separate them. The vein-stones present often a great practical difficulty to the working of mines, by their irregular distribution. In some instances veins have been followed for a distance, and yielded pure ore, but suddenly a vein-stone set in which enlarged until it "eat out the ore," as the miners express it, and the matrix alone remained. This horizontal alternation of the ore and its matrix, has ruined the prospect of many a miner, and in veins thus affected great caution and sound judgment are required. The vein is quite sure to yield pure ore again at some point ahead, but the most profitable method of reaching it depends upon various circumstances. In many cases where this substitution of the vein-stone occurs, the ore is found dispersed through the adjacent rocks in small cubes along the line of the barren portion of the vein. These cubes are often very abundant, and are called "dice mineral." Instances of this character may be found at Mineral Point, Shullsburg, Wingville, Crow Branch Diggings, &c.

It is difficult to determine which of the substances spoken of above, is the most favorable indication of a good lode. Heavy deposits of ore have been found with all of them, or entirely free from any associates, and there is probably no necessary connection between either of them, and the barrenness or productiveness of the veins which they accompany.

I have thus far endeavored to point out the leading characteristics of the lead veins of Wisconsin. I have confined myself to facts without attempting to account for, or explain them. I have endeavored to keep all theories out of view while making observations in the field; the primary object being to find out what is, rather than how came it to be. Both these inquiries are apposite and important, but the first must always be answered fully and truthfully before a reliable answer can be given to the second.

The first, too, is of pressing importance, and its answer replete with practical results, while the latter has only an indirect bearing upon the economical value of the mines. If the miner is familiar with the rocks amid which he is operating, the laws which govern the veins, and the most frugal method of extracting the mineral wealth from those repositories in which nature has stored it; he has knowledge of far greater value than any abstract theory, however satisfactory. With this view, it has been my first object to collect such facts as would illustrate the character and extent of the mineral resources of the lead district, and stimulate their development in the highest possible degree. Still the origin of these veins is a matter of great interest, and ought not to be entirely omitted in this report. I shall therefore present those theories which have been most generally accepted, to explain the formation of metallic veins. Thus every observer will have before his mind what others have concluded upon this subject, and be enabled to decide for himself how far these views harmonize with the facts of which he is personally cognizant.

# CHAPTER IV.

## FORMATION OF VEINS.

The filling of mineral veins is one of the most difficult subjects in the whole range of geological studies. The more careful the investigation, the more fully aware is the student of the difficulties to be overcome. It is now quite generally admitted among geologists that several processes have been active in supplying veins with their metallic contents. There are four theories, each of which has been sustained by high authority, and all of which are undoubtedly true in their practical applications. First, The crevices or fissures are supposed to have been formed, and mineral matter, dissolved in water, to have been filtered into them from above. This theory was maintained by WERNER, but it probably applies to very few cases of veins. Second, The metallic ores are supposed to have been melted and injected into the rocks by subterranean forces, similar to those concerned in the protrusion of lavas through volcanic craters. Many veins have undoubtedly been filled, as they may often be traced to a mass of rock which has once been lava. Of this kind are the tin and copper lodes of Cornwall, England. This theory was first taught by HUTTON, and has been very widely adopted. Third, Another theory is that of sublimation, or the introduction of the metals in the state of heated vapor, which, upon cooling, condensed and formed veins. It is a well known fact that metals can be vaporized by heat, and that when in this state they naturally ascend and condense upon cooling. Crystals of galena, specular iron ore, and other metals, are thus formed in the laboratory, in the flues of furnaces, and the craters of modern volcanoes. Similar processes have no doubt been operative in all periods of the earth's history, and must have produced similar results; Fourth, Electro-chemical action is supposed to have been exerted, causing a segregation of metallic particles, and thus forming veins. The superior productiveness of the east and west veins is accounted for by the greater facility with which the segregation could take place from north to south, on account of a coincidence between the local and general currents of electricity. It is supposed that by this action constant decompositions, re-compositions, and transmissions are being effected. A wide variety of opinion exists among practical miners upon this subject. All these theories have their advocates, each basing his opinion upon the special and local facts which he has observed. The theory of formation from water is stoutly maintained by many who have seen the ore pendant from the roof of caves, associated with stalactites which are known to have had such an origin. But it is quite certain that this opinion is incorrect. The insolubility of galena in water, its crystaline character, and arrangement in veins, are all incompatible with such a supposition. If we take any one of the other theories mentioned, it fails to explain all the phenomena presented; but each receives support from some of the peculiarities which these veins exhibit.

It is not improbable, therefore, that each of these processes has been in some degree instrumental in producing and arranging these deposites of ore. They may have acted cotemporaneously, or successively, or in both methods.

In the lower deposites, generally arranged in flat sheets, we often find evidences of a highly heated condition of their contents. The rocks enclosing the vein are often harder and more crystaline than those at a distance. The ore and its vein-stone are sometimes intimately combined, resembling in texture the coarse granites and other rocks of igneous origin. In some parts of such veins a segregating force seems to have acted, separating these ingredients, or some one of them into layers, precisely resembling the veins of segregation so often seen in the igneous rocks. Almost every grade of texture may be observed among these vein-stones, as among different beds of granite, sienite and porphyry. These are entirely confined to the lower deposites, so far as my observation extends. The perpendicular veins carry pure ore, as before mentioned. This ore is attached to the roof, and side walls of their cavernous openings, but is rarely found in place upon the floor of the caves. If we suppose the fissures to have been open and the ore injected into them, such an arrangement could not have taken place. The fissure would be either completely filled in such an event, or its lower part only, occupied by the ore. It is far more in accordance with the phenomena to believe that the perpendicular veins were filled by the process of sublimation. The heat, which perhaps melted the lower flat sheets, might be sufficient to vaporize a portion of the galena, which passing upwards into the vertical fissures, would condense and arrange itself in their upper portions, as we find it now. The absence of vein-stones in these veins is accounted for by this theory, as the lead ore would be volatilized and carried upward, at a much lower temperature than its associates.

Another interesting evidence of vaporization, is the occurrence of the casts of fossils formed by the introduction of Galena into the cavities of shells, corals, &c., The tubes of delicate corals, sometimes scarcely larger than a hair, are occasionally found filled with the ore; and also the stems of encrinites. I have also a specimen of crystalized galena, which has been formed in and around a mass of fossil shells, that have evidently been first worn by water to mere comb. The ore had then been introduced among these delicate remains, and received the impressions of its constituent shells. Evidently, in these instances the galena must have been in a state of very minute division, and endowed with perfect freedom of motion; conditions which could only be realized by its vaporization. In the absence of sufficient data to warrant a conclusive opinion, I have stated the prevailing theories, and such application of them as seemed most in harmony with facts. From the desultory and irregular manner in which the mines have been worked, it is very difficult to collect facts upon the most intricate points presented in these veins. The observations made may serve as a nucleus for future facts and discoveries, which in due time, if faithfully gathered, will point out the true theory of their formation.

# CHAPTER V.

## SURFACE INDICATION OF LEAD VEINS.

There are various indications of the presence of lead veins, all of which are more or less reliable. The general character of the ground is first noticed. A surface cut by frequent ravines, or presenting longitudinal depressions is always preferred, as these indicate the existence of fissures in the rock below. The discovery of "float mineral," or more properly "shovel mineral," is reliable evidence that a vein exists at no great distance from which the scattered ore has been separated. It is usually found in vallies on the sides of slopes, or in beds of clay upon the level surface.

Scattered pieces of tiff, or vein-stones of any kind, are good indications of the same nature as that just mentioned. The growth of vegetation in a linear direction, is also relied upon, as pointing out the location of a crevice which may hold "mineral." Certain plants which thrive best in deep soil, choose such locations as furnish the greatest depth of soft ground. Along the line of the veins their deep reaching radicals meet with no obstruction. Hence, lines of rank vegetation often form a prominent object among the surrounding growth, and mark the location of fissures in the rocks beneath. A notion prevails very widely that a certain plant, known as the "masonic" or "lead weed," grows only where its roots are fed by lead ore. This plant is noted for the depth to which its radicals are known to pierce. They are often found from 40 to 60 feet below the surface. It is therefore usually found growing over crevices where its subterranean proclivities can be indulged without restraint. This indication is said to have been learned from the Indians, who used it long before the lead veins of this district were known to the whites. These are the ordinary tangible evidences upon which the miner relies in "prospecting." They are fonnded upon the well known relation of things, and experience has proved their genuineness. Certain other processes of discovery are practiced by some. The use of various forms of the "divining rod," is the most common of these.—From its cheapness and simplicity, it is within the reach of all, though it refuses to exert its enchantment except in favored hands. An instrument called a "tinkembob," much more expensive, but also said to be more reliable, is occasionally met with. As these methods of discovery are entirely arbitrary in their character, and have no reference to the truths of mining science, they are beyond the jurisdiction of my present investigations, and in the absence of all positive knowledge, I cannot venture an opinion upon their practical value to the explorer.

In prospecting, a general knowledge of geology would be of great service to the practical miner.

Untold thousands of money, and long years of toil have been wasted for the want of such knowledge. The lead region is covered with "prospect shafts," sank where the veriest tyro in geology would have pronounced an unconditional negative upon the hope of "striking a lead." The adventurous swarms of "prospectors" who sweep over the mines during the excitement of first discovery, left few of the surface veins unopened. Hence, prospecting is now attended with great risks, and requires superior sagacity and extensive knowledge for its successful prosecution.

# CHAPTER VI.

## WORKING OF THE LEAD VEINS.

It is quite certain that the existence of lead ore had been known to the Indians, long previous to the commencement of mining by the whites. Their ancient works still remain to attest the fact. These consist of shallow diggings, and wide furnaces in which the ore was smelted. The natural sagacity of the Indians made them successful prospectors, but, destitute of tools or skill in operating, they seem to have made slow progress in proving their discoveries. Their working consisted mainly in picking over the soft clays of the surface, or the larger crevices with hatchets rude sharp sticks. When their shafts became a few feet deep, and ladders were made by cutting off the branches of small trees, about a foot from the trunk. Upon these the squaws, who performed all the labor of mining, descended and ascended, carrying in bags and baskets, all the ore which they obtained. These rude ladders were occasionally found among the old "Indian diggings." In some cases they ran levels a short distance into the sides of the hills, upon veins which they had discovered, using mats and blankets as sleds to draw out the rubbish. Where the vein entered the solid rock, they made fire upon it, and when heated, poured on water, by which it was cracked, and rendered easy of removal. Their metallurgy was equally rude and simple. A rude hopper was built of stones, usually upon the side of a ravine. Into this the ore was thrown and a fire kindled beneath. When melted, it was run off into a hole dug for its reception.

Such rude attempts at mining seem to have been made, previous to any acquaintance with the whites. Later, however, the

French traders furnished the Indians with tools, and instructed them further in the art of mining. They also purchased their ores, and gave them in exchange, such articles as they required. This stimulated them to farther exertion, so that from 1816, to 1820, considerable quantities of ore was raised by them, which was sold to the traders and found its way to St Louis. American mining commenced about 1820, but no considerable amount of ore was raised until about 1827. The lead region then began to attract popular attention. A few bold pioneers were already in the mines, and amid all the perils of Indian warfare, remained. As soon as the war closed, they recommenced their mining with renewed vigor. The fame of their discovereies went abroad, and brought to the mines thousands of adventurers, who swept over every hill and valley in search of the mineral treasures they were reported to hold. Brilliant discoveries were made, and splendid fortunes acquired. The ore lying near the surface, was of course first found, and requiring little skill to secure it, mining was exceedingly simple. No machinery was needed for draining, and no large outlay of capital was required to insure returns. Under such circumstances, no regular or systematic mining could be expected. Every man was a prospector and preferred breaking ground for a new lead, to working for wages, or moderate returns, in ground already proved. During the twelve years, from 1830 to 1842, machinery was hardly thought of. It was the period of excitement and discovery which always attends the opening of a new mining district. Since that time, very few new discoveries have been made, and the work has been mostly confined to old lodes. With few exceptions, even now, the mines are very ineffectually worked. The shafts have been sunk with no view to permanence. Drifts are run off from them wherever indications of ore appear. If the ground is soft they are supported by temporary cribbing. The rubbish and ore are raised by a common windlass, in wooden tubs called "kibbles." The digging generally ceases at the water line. If however, the vein is strong enough to warrant it, a lifting-pump worked by horses or oxen, is put in.—

In a few instances only, steam power has been used in working pumps; but from the incapacity of the engines, or injudicious management, it has failed to be profitable. During the present season two engine pumps have been started under more favorable auspices. One at Potosi, by Mr. Lewis, and the other at Fairplay by the American Mining Company. Both these parties have ample means at their disposal, and are determined to make a fair experiment. Water-power has been used in one or two instances, and might be profitably employed in numerous localities. With these exceptions, all the labor of the mines is performed either by hand or horse power.

# CHAPTER VII.

## PRODUCTIVENESS OF THE MINES.

In order to exhibit properly the condition and value of the mining interest of the Wisconsin Lead District, I have carefully collected from all sources within my reach, such statistics as could be obtained, and am enabled to present a table, showing the annual productiveness of the lead mines, during most of the period since 1823. The product for the first seven years, from 1823 to 1830, I extract from the report of Dr. OWEN, made to the general government in 1840. The remainder of the table was supplied by Capt. CHARLES BEEBE, of Galena, whose acurate habits entitle his statistics to the fullest confidence.

### A TABLE

*Exhibiting the amount of Lead shipped from the Lead District of Wisconsin, Illinois, and Iowa, from the year* 1823 *to* 1853, *inclusive.*

| YEAR. | POUNDS. |
|---|---|
| 1823 | 385,180 |
| 1824 | 175,320 |
| 1825 | 664,520 |
| 1826 | 958,842 |
| 1827 | 5,182,180 |
| 1828 | 11,105,810 |
| 1829 | 13,343,150 |

Here follows a period of eleven years, for which we have no statistics, owing to a change in the mining regulations.

| | |
|---|---|
| 1841 | 31,696,980 |
| 1842 | 31,653,330 |
| 1843 | 39,148,276 |

| Years. | Pounds. |
|---|---|
| 1844 | 43,729,540 |
| 1845 | 54,497,860 |
| 1846 | 51,368,210 |
| 1847 | 54,634,450 |
| 1848 | 47,737,830 |
| 1849 | 44,605,380 |
| 1850 | 39,801,130 |
| 1851 | 33,188,056 |
| 1852 | 28,703,960 |
| 1853 | 29,806,980 |

From this table it will be seen that the annual yield of the mines went on increasing to 1845, when it attained its maximum, and remained nearly stationary for three years. From 1848 forward, a steady decline is shown, bringing us by a constantly decreasing series to a product nearly fifty per cent. less in 1852 than 1847. A decrease so marked and rapid in the productiveness which had been constantly increasing for thirty years, proves the operation of some powerful and wide-spread cause. This cause it is highly important to ascertain and make known, for in the absence of authentic knowledge, serious misapprehensions exist abroad in regard to its true nature. It is generally supposed that the deposits of lead are nearly exhausted, and therefore hold out no inducements to business men to engage in working them. Hence, while capital has been freely flowing to other mining districts far less rich in metallic ores, no non-resident company has ever made an investment in the lead mines of Wisconsin. Unfounded in fact as this report may be, it has nevertheless done much to injure the mining interest, and at this time exerts a strong influence against it. The real causes of this diminished product are well known to those familiar with the history of our lead mines.

First, while the mines were at their maximum productiveness, the discovery of gold in California was announced, and drew off one-third of the whole mining force. This was a loss that could not be replaced, especially while the whole tide of adventurous emigration was flocking to the land of gold. The following extract from the Shullsburg *Pick & Gad* presents the conviction of all who are acquainted with the loss thus experienced:

"Although science may do much in developing our mines—a scientific research bring out and establish new principles—yet we feel that if we had among us that population which opened the diggings which we are now working,—if we could call back from California some of those enterprising young men who have left within the last four years,—could we gather up the bones of those brave miners that are bleaching upon the far-off plains of Mexico, and re-animate that dust which is mingling with the ashes of the Aztec,—could we people the mines with the population of '40 and '46—we would again hear the cry of new diggings, new lodes, new towns, and a change would come over the spirit of this dreaming, gophering community, which, with a few exceptions, are drifting around and picking up mineral upon the discoveries of those brave boys who were always in quest of new things."

As a second cause, the prevalence of an irregular and inefficient method of working the veins may be mentioned. This has already been described in a former paragraph. Such working answered well enough as long as there was surface ore enough to pick up; but when the superficial deposits were exhausted, it was inadequate, and a falling off in the product could not fail to follow.

The mines have been worked entirely with a view to immediate results, and generally by single individuals, or small and temporary combinations, with little capital at their command. The working of veins at any considerable depth involves an expenditure too large for any except companies with heavy capital. The reason will be seen at once, when the nature of the operation is considered.

In following a vein, dead or barren ground is often encountered, as already noticed, and the miner must work through these unproductive portions in order to reach the deposits of ore. The distance that he must work without receiving any returns is uncertain, but it is quite sure that somewhere before him, the vein will resume its productiveness. The constant hope of discovery stimulates him to effort, and not unfrequently poverty and want spur his limbs to the uncertain task. After years of toil, he perhaps strikes a lead, and is repaid for all his sacrifices; or, as not unfrequently happens, worn out in body, discouraged and beggared, he abandons his shaft forever. Another miner, bringing fresh energy and capital, steps into his place, and taking up the work where he had been compelled to leave it, soon finds an opening which yields a competency or a fortune. In some cases, shafts or drifts have been worked by several sets of miners successively, and abandoned by each, where at last some fortunate individual comes in, strikes a lead, and alone reaps the reward of their united labors. The history of these adventures would furnish instanecs of manly fortitude and persevering toil which have never been surpassed. We know those who have succeeded; but the long, sad catalogue of those who failed, is lost in the obscurity of poverty and the grave. Such experience proves that the risks of mining are too great for single individuals with small capital, and very few can now be induced to attempt it, who thoroughly appreciate the small chances of success.

The system of individual mining is also a serious obstacle in the way of drainage. Owing to the limited size of individual claims, one mine often cannot be drained by a pump or level, without receiving the water from several others belonging to various owners, and unless some arrangement can be effected among them, the ground remains unworked, for no one would be willing to bear the whole expense of drainage where all are to share its benefits.

The development of the mines has also been retarded in some localities by the illiberality of non-resident land owners, who demanded exorbitant rents, and desired to throw all risks upon the miners. Many rich lodes have been left unworked, to the damage of the owners, as well as other parties interested.

Under these depressing circumstances, mining could not long be profitable in any district, and we are not surprised that our mines have diminished their product one-half in the last five years. Suppose such a system tried in the metalliferous districts of Britain and Germany. Would not their great metallic arteries, which now flood the markets of the world, dry up, or shrink into insignificance?

Mining, like manufacturing, requires for its successful prosecution, systematic, comprehensive, and long continued application of labor and capital. Individual mining can be profitable only for short periods. It lacks the force, and has not power to avail itself of the economies essential to success. Individual interests and capital must be combined and brought under the influence of a common aim. Risks and benefits must be shared, force must be organized, and guided by intelligence and skill; then nature can be conquered, the difficult problem solved, and the gate of her stony treasuries opened in triumph.

The mines are now in a transition state. They have passed through the period of excitement, when chance rewarded the fortunate with rapid gains, to a more quiet and settled condition, in which rude and individual attempts at mining are attended with frequent failure and occasional success. They now await the period of organization to which their full treasures are to be surrendered.

## CHAPTER VIII.

## VALUE OF THE LEAD MINES OF WISCONSIN, AS A FIELD FOR EXTENSIVE MINING OPERATIONS.

In opening an extensive mine, a large expenditure must be made before any return can be realized, it is therefore important to calculate closely beforehand the conditions required to render this preliminary investment a profitable adventure. This involves several considerations, each of which must have its due weight in determing the value of a mining locality.

First—The character of the metalliferous deposits.

Second—Extent of unworked ground, where discoveries of ore may reasonably be expected.

Third—Character of the ground.

Fourth—Facilities for drainage.

Fifth—Proximity to fuel, market, &c.

Let us now see how the lead region of Wisconsin will abide the test of these conditions.

First—Character of the deposits. I have already shown that most of them are true veins and may be relied upon as such in extensive mining operations.

Second—Extent of unworked ground. It has also been shown that the works thus far have merely been superficial. The deposits of the surface rock even have only been exhausted in a few cases, while those of the lower rocks have but just been discovered. All the mining thus far done could be put upon six sections of land. Veins are everywhere pointed out which have been abandoned, though still yielding richly, for want of machinery to remove the water, or from the occurrence of a temporary "pinch" which cut off the ore. The constant discovery of veins incidentally while digging wells, cellars, &c., proves conclusively that a vast addition to the known mineral ground may be looked for in this direction; while the unexplored deposits of the buff-colored and lower magnesian limestones, offer a fresh and promising field to mining enterprise. From those rich storehouses of ore, generations to come will draw their supplies and leave them yet unexhausted.

Third—Character of the ground. This is eminently favorable. The veins intersect only limestones, sandstones, and shales. No injections of trap or granite occur here, which so often ruin the prospect of the miner elsewhere. The rocks have been very slightly disturbed, hence faults or shifts of the strata, throwing the veins out of their natural position are rare. The ground is frequently so open that nothing but the pick and gad are required for excavating it.

Fourth—Facility of drainage. As most mineral veins run into the water at a short distance from the surface, it is important to know with what facility this element can be removed. This will depend upon the structure of the rocks and the conformation of the surface. Near many of the lodes the surface is intersected by deep ravines and vallies, on either side of which the lead bearing rocks are piled. In such cases drainage by level can be very easily effected. This method of drainage has advantages over every other where it can be used. As the veins are arranged in gangues, parallel to each other, a level may be run so as to cut them all in its course and thus prove the ground at the same time it relieves it of water. Such a level, judiciously located and perseveringly driven could not fail to enrich it owners. Numerous localities might be selected, where by running a level one mile, from twenty to fifty veins would be cut through and drained. A few levels only have been undertaken. That of Mr. Champion at New Diggings is the most extensive, and has been eminently profitable.—Mr. Loony's level, near Benton, has been driven 900 feet, and paid well. McCoy's level, near Shullsburg, is also a good investment. These are only beginnings, but they prove what may be done in this direction.

In Europe, these levels are often driven for many miles, at an expense of from five to twenty dollars per fathom. One of these levels, at the Gwennap mines in Cornwall, is twenty-six miles in length.

The lead mines of this district can also be readily drained by pumps of moderate capacity. The lead-bearing rock is traversed by vertical seams, filled with a tough clay impervious to water. By this means, the water which it holds is divided into separate basins, or great natural cisterns, each independent of every other. Thus, a pump may be put upon any one of these, and unwater the ground within its limits, while those adjacent are not affected. Were it not for this beautiful economy of nature, no pump could be found of sufficient power to lower the level of these subterranean waters. This structure also explains the fact, that the water is often found twenty or thirty feet higher upon one vein than upon another a few rods distant. In some cases, the basins are so small that forty feet of water has been raised by a pump of three-horse power. In other cases, fifty-horse power would be required to effect a thorough drainage.

Fifth—Location in respect to fuel, market, &c. The lead district as a whole is abundantly supplied with fuel, though in some few localities, wood has to be brought from a distance. The dense forests of its river valleys, and the heavy bodies of oak and other timber which cover nearly one-third of its surface, promise a store of fuel amply sufficient for its future wants. The great coal field of Illinois is scarcely a hundred miles from its southern border. Lines of railway, traversing it from east to west, and from north to south, will soon connect it with those vast stores of combustible matter, and disperse the spoils of its own forests wherever the wants of industry may require them. It is thought that under these facilities for cheap transportation, coal may be afforded at $2,50 per ton. At this price, it could be safely used in those portions of the district where wood is least abundant. The completion of the railroads, now being rapidly constructed through this district, will give it, together with its proximity to the Mississippi, ready access, at every season of the year, to all the markets of the country.

I have thus endeavored to set forth the character of the lead mines of Wisconsin; the causes which have obstructed their development; and the inducements which they offer for extensive mining operations. It has been shown that the deposits of ore are true veins; and unexhaustible for centuries to come. That as yet they have been worked only in the most superficial manner; that the withdrawal of labor into other fields, the want of concentrated capital, and the prevalence of mistaken opinions as to their value, have all been operative in retarding their progress, and bringing their productiveness to a temporary decline. Yet even under these unfavorable circumstaaces, these mines yield annually nearly 30,000,000 lbs. of pure lead, or about one-half of all the lead produced in the United States. During the years 1845, 1846 and 1847, the entire lead mines, including the small portions of the district in Illinois and Iowa, produced annually about 54,000,000 lbs., of which two-thirds were from the Wisconsin mines. During the same years, the average annual yield of all the lead mines of Great Britain was 105,736,333 lbs. The yield of our lead district, therefore, exceeded one-half of the total product of the British lead mines. Such a product of ore, with the some outlay of labor and capital, is altogether unprecedented in the whole history of mining.

During these years, lead became an important item in our foreign exports, while the import of this article sank to a mere trifle. This will be seen by consulting a few statistics from the records of trade. During 1845 and 1846, the imports and exports were as follows:

| *Imports.* | *Rec'ts at New Orleans.* | *Exports.* |
|---|---|---|
| 7,995 lbs. | 54,930,000 lbs. | 16,823,766 lbs. |

In contrast with these figures, observe the same statistics for the last two years—1850 and 1851:

| | *Imports.* | *Rec'ts at New Orleans.* | *Exports.* |
|---|---|---|---|
| 1850-51— | 43,490,000 lbs. | 22,750,000 lbs. | 227,448 lbs. |
| 1851-52— | 37,544,588 " | 18,729,580 " | 747,930 " |

According to these figures, in the years 1845 and 1846, we not only supplied our home market with lead, but sent to foreign countries 16,000,000 lbs. While during 1850, '51, and '52, we have fallen so far short of supplying our home market, that we import annually 40,000,000 lbs. to make up the deficit. For this we send out of the country annually, about $2,500,000 for a commodity which might be abundantly supplied at home. Two-thirds of this sum of money sent away to pay the miners of England, Germany, and Spain, ought to be laid out in the lead mines of Wisconsin, and would be, if these mines were worked to an extent at all commensurate with their inherent richness. It is obviously of the highest importance that an interest like this, second to no other in our State, should not be suffered to decline. At this period especially, when we are just setting up for ourselves, we need the avails of those natural resources with which a beneficent Providence has favored us. If our young State would become rich in acquired possessions, it must improve this fundamental capital. It should buy much, but sell more, and buy nothing abroad that it can get at home. What a transformation would the vast sums now sent abroad for lead accomplish, if distributed over our lead district, for which nature has done so much, and art so little.—What engines would pump its deepest mines! What mighty levels would be cut through the walls of its veined treasuries!—What life would be infused into every branch of industrial effort! What cities would grow up as if by magic; and what evidences of wealth and prosperity would cover all the land! For such a consummation, a little fostering care only is now needed. The true value of these mines must be made known; and companies with ample capital must be found to work them. A Department of Mines, similar to the School of Mines in Great Britain, should be connected with the State University, where such scientific knowledge as is necessary for successful mining, may be obtained.

Under the present high prices of lead, the mines are reviving, and it is to be hoped that no change of governmental policy will result in a reduction of these prices until they are again in a state of healthy activity.

# CHAPTER IX.

## ZINC ORES OF WISCONSIN.

These ores (popularly known as "black-jack," and "dry-bone,") are found in quantity in the lead district. They are generally supposed to be worthless, and hence are thrown away among the rubbish of the mines, no thorough attempt having been made to ascertain their value or to reduce them to use. Impressed with the importance of ascertaining their true quality, I have caused them to be thoroughly examined and analyzed, with a view to determine their workable value. The experiments thus far have been made with the dry-bone, as the black-jack is better known, and from its peculiar composition is a less valuable ore, being practically valueless here, from the great expense attending its reduction.

The examinations were conducted by Dr. AUGUSTUS HAYES, of Boston, whose distinguished reputation as a chemist, and large experience in the assay of similar ores, will inspire the fullest confidence in the correctness of his results. His report upon the zinc ores submitted to him, is given below, and shows that this dry-bone contains from 79 to 90 per cent. of the oxide of zinc, four-fifths of which is pure metal. This large per centage of metal is so favorably combined as to be readily separated by known processes from the ore.

The examinations were conducted at my request, with especial reference to the capacity of the ore to yield the white oxide of zinc, which, from its great value as a pigment, is becoming an article of the highest importance in the market. The results are of the most favorable character, proving the existence of a new source of mineral wealth in this district, second only to its wonderful lead veins. The oxide of zinc, or zinc white, is now rapidly superceding white lead as a paint, owing to its quality, absence of poisonous effect and greater cheapness of production.

To supply the great and constantly increasing demand for it, we have in the United States only two manufactories: one in New Jersey and the other in Pennsylvania. The New Jersey works have been in operation about three years, and have prepared their paint from the red oxide of zinc, which, until recently, was supposed to be the only ore capable of yielding zinc white, without first reducing it to a metal. A recent discovery, however, has been made, which proves this supposition to be an error. An ingenious metallurgist, SAMUEL WETHERELL, Esq., has discovered a process of manufacturing this article from the dry-bone or carbonate of zinc. The Pennsylvania works have been erected for the purpose of applying this discovery upon an extended scale, to a deposite of dry-bone discovered and owned by SAMUEL SMITH, Esq., of New York, to whose enterprise, and that of Mr. WETHERELL, the public are indebted for this important addition to the available resources of the country. The works have just been completed and commenced operations. An extract from the American Mining Journal will show the success of the invention in practice:

"The assertion that the oxide of zinc could not be made from the calamine, (dry-bone,) unless by first reducing the zinc to a metallic state, and then sublimating it, has been proven, within the present week, untrue. This fact is not merely the result of analytical experiments, but is daily accomplished, making four tons of oxide of zinc, or twenty-four tons per week. We learn from an officer of the company, that they will at once proceed to enlarge their works and increase their product to ten tons per day, or 3000 tons per annum. This at $130 per ton, would amount to $396,000, which, ground in oil, would sell for $180 per ton, or $540,000 per annum. These estimates may be relied upon as demonstrated by the actual working of the manufactory. The white oxide produced by this process will compare favorably with the best French white, besides being superior to it in body."

Dr. HAYES has shown that our ores are fully equal, if not superior, to those of Pennsylvania. They are found in sufficient abundance to supply extensive works with raw material. They could be obtained very cheaply, both on account of their frequent association with lead veins, and the quantities already thrown out upon the surface, in mining for lead. They are within 150 miles of Milwaukee and Chicago, to which points they will be connected in one year, by railway communication. To these places they could be conveyed at a cost of $1,50 or $2,00 per ton. If preferred, coal could be transported inland at corresponding prices. Every ton of ore will yield from 1400 to 1600 pounds of pure white oxide. This could be sold at the door of the factory for $130 per ton. The cost of the ore and manufacture would not exceed $60 per ton, leaving a clear profit of $70 upon every ton of the oxide manufactured. A factory producing ten tons of oxide per day, would thus yield to its owners a net annual profit of $210,000. This is no fiction. These results are realizable, and will be realized, when capital, enterprise, and skill are organized and brought to bear upon this new branch of our natural resources. The manufacture of metallic zinc and brass might also be profitably conducted with this ore. For this purpose it is the best ore known, and is used in Europe in preference to any other. All of our zinc and most of our brass is now imported, while our mines of zinc and copper are second to none in the world. We need only patience, skill, and confidence, to conquer the slight difficulties which now lie in the way to these great sources of wealth and prosperity, with the means of which we are so abundantly provided. I commend attention to the accompanying report of Dr. HAYES.

## REPORT OF DR. AUGUSTUS HAYES, UPON THE ZINC ORES OF WISCONSIN.

To EDWARD DANIELS, Esq.,

*Geologist to State of Wisconsin.*

DEAR SIR:—I am able at this moment to send you the results obtained by chemical analyses of the ores of zinc, which were among the valuable ores and minerals you placed in my hands:

No. 11 of the series. (Dry-bone diggings, near Shullsburg.) The specimen is a carbonate of zinc, with accidental portions of carbonates of lime, iron, and manganese.

One hundred parts of this ore consist of

| | |
|---|---|
| Pure oxide of zinc, | 59.76 |
| Oxides iron, manganese, and lime, | 4.84 |
| Earthy matter, or rock, | 1.40 |
| Carbonic acid and water, | 34.00 |
| | 100.00 |

One hundred parts of this ore, after roasting or heating to redness, contain 90.50 pure white oxide of zinc.

No. 12 of the series, from Platteville. The specimen is a carbonate of zinc, with a little silicate of zinc and carbonate of lime.

One hundred parts of this ore consist of

| | |
|---|---|
| Pure oxide of zinc, | 60.29 |
| Silica and oxide of iron, | 2.29 |
| Carbonate of lime, | 12.69 |
| Carbonic acid and water, | 24.00 |
| Earth or rock, | .40 |
| | 100.00 |

Specimen No. 12.—One hundred parts of this ore, after being heated to redness, contain 79.20 of pure white oxide of zinc.

No. 13 of the series, from Mineral Point.—This specimen closely resembles No. 12, consisting of carbonate of zinc with rock.

One hundred parts consist of

| | |
|---|---|
| Pure oxide of zinc, | 56.20 |
| Oxides iron, alumina, &c. | 1.80 |
| Carbonate of lime, | 2.00 |
| Silicious rock, | 6.60 |
| Carbonic acid and water, | 33.40 |
| | 100.00 |

One hundred parts, after heating to redness, contain 84 3-10 parts of pure white oxide of zinc.

No. 14 of the series, from Mifflin.—Carbonate of zinc, with some earthy matter.

One hundred parts consist of

| | |
|---|---|
| Pure oxide of zinc, | 57.00 |
| Oxides iron, alumina, &c., | 5.40 |
| Earthy matter, | 7.60 |
| Carbonate of lime, | 2.00 |
| Carbonic acid and water, | 28.00 |
| | 100.00 |

One hundred parts of this ore, after having been heated to redness, contain 79 1-10 parts of pure white oxide of zinc.

No. 21, of the series, from Messersmith's, near Dodgeville.—This specimen is also a carbonate of zinc, mixed with earthy matter, mostly silicious.

One hundred parts of this ore consist of

| | |
|---|---|
| Pure oxide of zinc, | 56.20 |
| Oxides iron, alumina, &c., | 2.80 |
| Carbonate of lime, | 1.80 |
| Silicious rock, | 6.20 |
| Carbonic acid and water, | 33.00 |
| | 100.00 |

One hundred parts of this ore, after having been heated red hot, contain 83 9-10 parts of pure white oxide of zinc.

The value of white oxide of zinc as a pigment, is becoming generally known, and it has a market price much higher than white lead. Most of the metallic lead consumed for paints is first made into white lead, which thus becomes the staple manufacture based on metallic lead. Now these ores of zinc, familiarly known as "dry-bone," are the best ores for producing the white oxide of zinc; but the manufacture is not here based on the metal, but on the ore. By merely heating these ores in heaps on brush-wood, they lose their carbonic acid and water, and become soft mixtures of from 79 to 90 per cent. oxide of zinc, with earths and iron oxide. The material thus obtained, mixed with charcoal, gives in the muffle furnaces, by one operation, nearly all the oxide of zinc which the ore contains. Extensive manufactories can be sustained by the consumption at present going on, of this product, which continues to be imported largely. But these ores are equally as well adapted to the production of metallic zinc, a very useful metal, bearing a higher price than lead. The ores used abroad for the production of this metal, are far inferior to these in quality, and they are not extensively distributed. On economical considerations, therefore, these ores have a high value. They offer the advantage of employing a large capital with a certainty of the manufacture being profitable and important. A state possessing such mineral deposits, must be regarded as rich in resources of a highly important kind.

Respectfully,
A. A. HAYES,
*Assayer to State of Massachusetts.*

16 Boylston St., Boston,
31st Jan, 1853.

# CHAPTER X.

## AGRICULTURAL CAPACITY OF THE LEAD REGION.

The best mining districts of the globe are generally noted for their sterility. This is not, however, always the case; and indeed there is no necessary connection, between metallic ores and unproductive soils. But the igneous rocks with which these ores are very generally associated, and the broken surface which accompanies them, are unfavorable to agricultural pursuits. In this region, however, we have no igneous rocks exposed, and the surface is generally only slightly undulating.

The soil is generally a rich, calcareous, and silicious loam, with a sub-soil of clay. In the north and east, where the sandstone comes to the surface, patches of sandy soil occur. Its fertility is attested by the actual results of farming whenever attempted—a testimony far more tangible and satisfactory than could be given by any analysis, however complete. The most abundant crops of wheat, corn, oats, rye, barley, potatoes, &c., are returned to the farmer. Fruit trees of every variety known in our northern latitudes, thrive vigorously and bear abundantly. Some of the producing orchards of this region cannot be surpassed in the country. Even the grape seems at home, and ripens finely in the dry, pure atmosphere peculiar to our State. Tobacco and flax thrive wherever tried. The traveler who passes over this region, when the crops are waving in the luxuriance of summer, and the orchards bending beneath their fruitage, will need no aid from the geologist and chemist to convince him that its soil is of the best quality.

Living water is abundant here. Springs gush out from every hill-side, and streams flow in every valley, whose crystal waters are equal to any that the poets have ever feigned or sung. Thus water for stock can be easily obtained—a prime consideration in the selection of a farm. The streams are generally rapid, and furnish excellent water-powers for milling and manufacturing.

Timber is also abundant, with the exception of a few large prairies; yet even on these there are no points more than three or four miles distant from the wood. An interesting and valuable feature may be mentioned in this connection, viz: The rapid growth of young trees from the soil of the open prairie, wherever the annual fires are shut off. Upon Judge BLACKSTONE's farm, near White Oak Springs, we were shown dense groves of young trees, from six to ten inches in diameter, where, twenty five years ago, not a shrub could be found larger than a riding whip. The same process may be seen in numerous localities, at various stages of advancement, from the prairie, covered with sprouts of oak, hickory, aspen, hazel, and sometimes maple, linden, and ash, to thick groves which have been growing for many years. In what manner have the germs of these trees been preserved in the soil of the prairies from which they spring, during the long period that they must have remained dormant? If proper precautions are taken to protect the surface from the fires, every farm upon these prairies will supply itself with timber in a few years. No uneasiness need be felt in regard to wood in this district, as the growth will far more than replace the use, and self-interest will dictate the preservation of young trees.

Its proximity to the great pine regions of the north, renders lumber cheap, and easily obtained. Its location, in point of access to market, with the Mississippi on the west, and about to be connected by three lines of railway with the east; cannot be surpassed. It possesses every needed facility of communication to give a good market for its agricultural products. The home demand now absorbs whatever the farmer can raise, at high prices. The prices of lands are very low, considering their quality and location. Here, then, we have in the lead mines every essential to the successful prosecution of agriculture; a fertile soil, wood, water, timber, and a ready market at home or abroad for every thing produced; a fine climate, and cheap lands. We may justly claim for this district agricultural resources equal to any other in the great valley of the Mississippi.

We can safely commend it to the agriculturist who is seeking a location. Laboring under mistaken ideas of its character, regarding it as dry, sterile, and broken, the tide of agricultural emigration has swept by, to lands inferior in quality and far less favorably located. Let the emigrant in search of a farm look over the beautiful counties of Grant, Iowa, Lafayette, Green, and Dane, before he goes farther west, and he will hardly fail to find one to his mind. A vast accession to the farming population of the district may be expected as soon as these erroneous impressions are removed. Its prairies and openings will be laid out into farms, whose owners will enrich themselves from the products of the fertile soil. Its hills and vallies will be dotted with rural homes, adding new beauty to the charms of nature; and its solitudes will be made glad by the stir of happy and successful industry.

# CHAPTER XI.

## MINERALOGY.

Under this head, I will present a brief notice of the prominent minerals of the lead district, and the processes by which those of them which are valuable may be prepared for use. For want of such accurate knowledge, mineral resources often remain unknown, or if known, undeveloped and useless.

### SULPHURET OF LEAD.—GALENA.

This is the ore from which most of the lead of commerce is derived. It is of bluish gray color, with a shining metallic lustre, sometimes splendent. Cleavage generally perfect, cubic, occasionally found fibrous and granular. In many localities the crystals are very perfect and beautiful. They are generally cubes, called by the miners "cogs." These are sometimes elongated, so as to form right square prisms, or the edges and corners truncated, forming octahedrons, and dodecahedrons. The ore is generally reduced in blast furnaces, and the lead is run into moulds, forming bars of about 70 pounds weight, called "pigs." The average yield is about sixty-eight per cent.

For the chemical constituents of this mineral, see the report of Dr. HAYES, on galena, at the end of this chapter.

### SULPHATE OF LEAD.—ANGLESITE.

This ore occurs in small quantities. It is generally found in crystals, nearly transparent, having a vitereous lustre and slight tinge of green. The galena is often studded thickly with these crystals, especially where it occurs in small cavities.

### CARBONATE OF LEAD.

This is known as "white mineral" among miners. It is found massive, having no metallic lustre or appearance. It is generally of a white or light gray color, but is somtimes colored darker. It fractures very much like a piece of compact limestone. It consists, chemically, of the oxide of lead, 85.46, carbonic acid, 16.54. It occurs with the galena, generally in soft ground. It is sometimes found in a pulverulent form, coating the galena, and known as "mineral ashes." It has resulted from the decomposition of that ore. It is valuable as an ore of lead. About 20,000 pounds were raised at "Brigham's mine," near the Blue Mounds, and small quantities have been found in many localities. It is sometimes confounded with sulphate of baryta, from which it can be distinguished in the manner I have described in treating of that mineral.

### CARBONATE OF ZINC.

This ore has very little of the metallic character in its appearance. It is massive, assuming sometimes a stalactitic or mamillary form, with a spongious texture, like encrusted moss. It is popularly known as "dry-bone." Its color varies from white, with a pearly lustre, to light brown and green. It occurs abundantly in veins, associated with galena, at Mineral Point, Dodgeville, Mifflin, Franklin, Platteville, Shullsburg, Hazel Green, and other places. It is the most valuable ore of zinc known. For a fuller account of this ore, see report of Dr. HAYES, and chapter on "Zinc ores of Wisconsin."

### SULPHURET OF ZINC.—BLENDE.

This ore of zinc, known as "black-jack," is very common. It is generally massive; color, green, brown, or black; lustre, resinous. Frequently in crystals, disseminated through the vein-stone or the adjacent rock. Fine crystalized specimens are sometimes mistaken for tin ore. For chemical composition, see table of analysis. This ore has been used for the manufacture of metallic zinc, but it is so much inferior to the carbonate, or dry-bone, as to be used with profit only where that ore cannot be obtained. It may be ground and used as a mineral paint.

### SULPHURET OF COPPER.

This ore is usually of a brass yellow color. It resembles iron pyrites, but is distinguished from that mineral by being easily cut with a knife, and failing to strike fire with steel.

### CARBONATE OF COPPER.

Generally of a light green, gray, or blue color; earthy and massive fibres, with a silky lustre; sometimes crystalized regularly, with a vitreous lustre, and deep azure hue. In this last form, it is often mistaken for crystals of colored quartz, and furnishes specimens of rare beauty. The carbonate and sulphuret of copper are generally combined. They occur in veins, usually perpendicular, in the lower beds of the gray limestone. They have been worked at Mineral Point, where they have yielded about 15,000,000 pounds of ore. Most of this was smelted in the vicinity, and gave from 15 to 20 per cent. of pure copper. No work has been done on these veins for several years, and it may be questioned whether present indications are sufficiently favorable to warrant an extensive outlay. A small vein, also, has been struck in the same rock at McKnight's copper diggings, section 8, town of Wayne, and copper ore has been found near Centreville. Indications of copper have also been observed in several other localities. But until further examinations be made, it is impossible to pronounce upon their value. No discovery of this ore has been made in the same vein with lead, so far as I am aware.

### IRON.—BROWN HEMATITE.

A variety of this ore is found occasionally, forming the matrix of the lead; color, brownish yellow; structure fibrous, when broken presenting often a mamillary surface. It accompanies the vein in parallel bands with clay. When ground, this ore forms yellow ochre. Red ochre, known as iron rust, is often found in immense quantities in the veins. It is often followed as an indication of a "lead." Its origin can be traced to the decomposition of iron pyrites.

### SULPHURET OF IRON.—IRON PYRITES.

This mineral is found abundantly throughout the mines. It is the brilliant substance, called sulphur or "mundic." It occurs in nearly every form known to the mineralogist, and furnishes specimens of unsurpassed beauty. Occasionally the galena is coated over with this substance. In some cases the rock near a vein seems to have been broken up, and pyrites introduced, cementing the mass together into a kind of breccia. The cavities are lined with octahedral crystals of a bronze color. This ore is often mistaken for gold, from which it is distinguished by not being malleable. The chemical composition of this ore is 55 parts of sulphur, 45 of iron. It is used for the manufacture of copperas, which is prepared from it by the simple process of leaching and evaporation. It is also used for the manufacture of alum, and sulphuric acid. The increasing demand for these articles confers a high importance upon this ore.

It decomposes very rapidly, when exposed to the air. Where piles of it have been thrown out around the mouth of a shaft, the soluble copperas, formed from its decomposition, is often washed down by the rains, and collected in the pools around, where it is left upon the evaporation of the water. In Mr. LOONEY's level, section 11, town of Benton, a most beautiful illustration of decomposition and recomposition occurs. A heavy vein of pyrites is here imbedded in very pure clay. The level has been cut through this, giving free access to the air. The ore has decomposed, forming copperas, which effloresces in delicate crystals upon the sides of the level. A portion of the sulphur has been left pure. Another portion, uniting with the oxygen of the atmosphere, formed sulphuric acid, which, uniting with the clay, produced the sul phate of alumina, or alum. All these substances may be seen here in the process of formation. Nothing can be more instructive to the naturalist, or more interesting to the reflecting mind, than the contemplation of these silent mutations of matter, constantly going on in the great laboratory of nature, around and beneath us.

### SULPHATE OF LIME.—GYPSUM.

This substance has been found in only one locality. It occurs at Fairplay, about 60 feet below the surface, in veins traversing a bed of clay. It is white, with a fibrous texture, and satin lustre. Owing to its great depth from the surface, the extent of the deposit cannot at present be ascertained. It is used as a mineral manure, under the name of "Plaster of Paris;" and also for taking casts, stereotyping, and as a cement. I believe this is the first discovery of gypsum yet made in the State, except in the drift.

### SULPHATE OF BARYTA.

This is the heavy spar of the miner. It is generally of a white or yellowish color, vitreous lustre, and so heavy as to be often mistaken for white lead ore. It has even been carried to the furnace and tried for lead; and upon failing to yield that metal, the report has been circulated that the "white mineral" has been tried and found worthless. It is however distinguished from that ore by a little care. It is softer than the carbonate of lead. It has a glassy lustre, while that is lustreless and earthy in appearance. The lead effervesces with acid; the baryta does not. This spar is ground and used as white paint, forming Venice White by combination with white lead. The article here is of good quality for such purpose, and is found in considerable quantities.

### WATER LIME.

Discoveries of this valuable substance have been made in several localities, which promise to be of value. But I am not prepared to report upon them until fuller examinations have been made. It is of great importance that good hydraulic cements should be furnished from the rocks of our own State, as we are now making heavy importations of this bulky article from abroad. Early and thorough attention will be devoted to an examination of all rocks, which promise to be useful in this particular.

## BUILDING STONE.

The rocks of this portion of the State furnish excellent material for building purposes, but great care is required in making a selection. The different layers in the same quarry often vary much in their texture and composition, so that close discrimination is needed to obtain such as will weather alike. In this climate, where sudden freezes are so common after winter rains, if a rock is porous it can hardly escape destruction, however hard and compact it may appear, when taken from the quarry. The water insinuating itself into the minute pores, expands suddenly by freezing, and bursts it apart. When stone is to be selected for an edifice, of any considerable value, especially if designed for public purposes, every precaution should be taken to ascertain the real quality of the rock, before it is used. For want of such care many of our public edifices in older states are only monuments of folly; and at this early juncture, while our cities are yet to be built, we may take advantage of their experience.

# REPORT OF DR. HAYES ON THE GALENA OF WISCONSIN.

The results of assays of seven specimens of galena, as marked and numbered by EDWARD DANIELS, Esq, Geologist to the State of Wisconsin, are as follows:

No. 2. East and west vein from Brigham's, near Blue Mounds. —A clean mass of galena.

One assay ton (2000 lbs.) of this galena, assayed for lead, afforded 1600 lbs. The lead obtained when assayed for silver, less 1 25-100 oz. silver.

No. 3. From a north and south vein, New Diggings.—Another variety of galena.

One assay ton, assayed for lead, afforded 1628 pounds. The result for silver hardly differed from No. 2.

No. 4. From an east and west vein New Diggings.—Another form of Galena.

One assay ton, assayed for lead, afforded 1580 pounds. The proportion of silver was the same as in 3.

No. 5. Fibrous galena, from Franklin, supposed to contain silver largely.—A sample differing from the last in form.

One assay ton, assayed for lead, afforded 1586 pounds. The proportion of silver was nearly the same as in No. 4.

No. 6. North and south vein, Potosi.—Sample differing in form from the last.

One assay ton afforded 1680 pounds lead. The result of the assay for silver was the same as in the other samples.

No. 7. East and west vein, Potosi.—Another variety of galena.

One assay ton afforded 1600 pounds of lead. This lead contained the same proportion of silver as the last.

No. 8. From a dry bone sheet, Messersmith's, near Dodgeville. —This sample was somewhat mixed with foreign matter.

One assay ton, afforded 1520 pounds of lead. The proportion of silver in the lead was the same as in the above.

The analytical trials here given were performed on samples of galena, presenting different physical characters, and two of them had the color, form, and hardness of argentiferous galenas. The proportion of silver estimated on the yield of lead, is remarkably near the same in the different samples. The silver in this minute quantity seems to belong to the galena, whatever may be its form, and its detection and separation are not easily effected.

The per centage of lead afforded, is that of an assay, and will serve as a guide in pointing out what returns should be obtained from smelting operations as carefully conducted.

It will be seen that the ores, after being broken from gangue, should produce 1600 pounds of lead, from 2000 pounds of ore, were the smelting processes perfect.

Respectfully,
AUG. A. HAYES,
*Assayer to State of Massachusetts.*

Boston, 20th January, 1854.

# CHAPTER XII.

## IRON ORE OF DODGE AND WASHINGTON COUNTIES.

This deposit of iron ore consists of a bed of great horizontal extent, included between layers of limestone above, and a bed of clay, underlain by limestone, below. It presents an occasional out-crop along a distance of fourteen miles, and may be traced, with frequent interruptions, through the whole distance from Iron Ridge, Dodge county, in a south-east direction, to the town of Hartford, in Washington county. It varies in thickness from 8 to 30 feet. It undoubtedly extends over at least ten or twelve square miles, constituting one of the most extensive beds of iron ore known. It presents every evidence of being an included stratum, having a distinct stratification conformable to the rocks above and below it. The whole formation of rocks dip slightly towards the east. The structure of the ore in place is usually that of small flattened nodules, cemented together. By partial decomposition, the ore on the surface has been separated into its constituent nodules, which resemble flax seed in their size, color, and greasy feel. This loose material is called seed ore. Occasional lumps of compact hematite occur, which seem to be a secondary form of the ore. The limestone adjoining the bed of ore is frequently discolored by it, and crystals of hematite occur, lining its cavities. True analyses have been made of this ore, the detail of which I have not by me at this moment. They prove it to contain about 50 per cent. of iron, combined with alumina, silica, manganese, &c.—This per centage is eminently favorable, as any addition of iron beyond 60 per cent. diminishes the working value of the ore, except for transportation. The combination is such in this case that the ore reduces readily, without the necessity of any flux except the accompanying clay. The experiments recently made upon the quality of the metal produced prove it equal in toughness to the best American iron. Two companies have been organized to work this ore—the North-Western Iron Company, and the Hartford Iron Company. The North-Western Company have now in operation a steam blast furnace at Iron Ridge, capable of producing from six to eight tons of pig iron per day. They contemplate erecting two furnaces, of a superior capacity to this, at the same place. I am informed by CHARLES BURCHARD, Esq., of Waukesha, an active member of the company, that pig iron can be produced at these works cheaper than at any furnace in America. The ore delivered at the furnace costs only fifty cents per ton. The immense forests amid which it is located furnish abundant fuel, while its peculiar composition renders it very cheaply reduced.

Not a single furnace for the manufacture of pig iron exists west of Indiana, except at Iron Ridge. The demand for this material is very great, and is constantly increasing. This deposit of ore is practically inexhaustible, and when extensive works are erected upon it, a source of wealth, whose value can scarcely be overrated, will be developed.

Of the operations of the Hartford Company, I have no definite information at hand. Among its principals, however, are numbered BYRON KILBOURN and HIRAM BARBER, Esqs., whose connection with such an enterprise entitles it to the confidence of the public.

The works of the North-Western Company have been placed under the superintendence of JAMES TOWER, an Iron Master of great skill and large experience.

This brief notice is given here merely to call attention to the value of this deposit of ore. The examinations upon which it is based were made two years ago, with the exception of a hasty reconnoisance the present season.

A thorough survey of the iron district will be made at an early day, and presented in a future report.

# COMMUNICATION OF H. A. TENNEY:

MADISON, December, 1853.

Prof. E. DANIELS, *State Geologist:*

SIR.—In compliance with your instructions I herewith forward a brief preliminary report upon the general physical features, soil, scenery, and some of the most characteristic features of the geological district surveyed during the past season, embracing the south-western counties of the state.

A description of so large a district, and in so brief a space as this communication, it is but proper to premise, must be taken for what it purports to be—a general one—not applicable always to particular localities, but to the country as a whole, and even then is to be received with some grains of allowance.

There is a great degree of uniformity in the general appearance and contour of the surface of the district. Its most striking features are its broad prairies and woodlands, steep and high ridges, contracted and deep ravines and gorges, and mounds towering far above the general surface. The summit level of the highlands is nearly uniform, averaging, apparently, about five hundred feet above the Mississippi river; and, from the many abrupt slopes, narrowness of the ridges, and rapid descent of ravines and watercourses, the drainage throughout is both speedy and complete.

The channels of the rivulets and rivers have uniformly sharp and angular outlines, strikingly different from the valleys of streams in the middle and eastern portions of the state, and characteristic of the hard and flinty deposites through which they have been excavated. Their walls or banks are always abrupt—often vertical, and of great height. There are no broad bottoms or alluvions, or large level tracts of upland—neither marshes, lakes, or any marks indicating their recent existence. The surface is every where too high and rolling to admit the existence of standing or stagnant water. The hills and ridges have a determinate shape and order of arrangement, in marked contrast with the irregularity and accidental form of the drift hills and ridges elsewhere—no traces of which deposite are found in any portion of the district under consideration. It must not, hence, be inferred that it is, in the common sense of the term, rough or broken. On the contrary, seven-eights of the surface might be advantageously cultivated. Springs are abundant, and wood and water generally diffused, so that there are but few obstacles to successful agriculture.

The surface soil of the prairies is generally a vegetable mold; but clay predominates in the timbered tracts. A sub-soil of clay every where prevails. In the absence of chemical analysis, the composition of either can only be inferred; but there can be little question that they possess all the elements essential to an enduring fertility, and are adapted to the cultivation of every variety of crops that flourish in a temperate climate. A heavy deposite of clay, of variable thickness from five to fifty feet, covers the stratified rocks, concealing them from view, except in the vertical grooves made by water courses, and upon the slopes of occasional declivities, which have a naked and barren appearance, contrasted with surrounding evidences of fertility. It seems probable, from examination, that the materials of this deposit were derived from the decomposition of the rocks whose place it occupies, and that it was of fresh water origin.

All the lower lands of the district are covered with a rank growth of vegetation, and for numberless ages have been enriched by its annual decay. Every rain transports fertilizing elements from the higher to lower levels, perpetually adding to the productive qualities of the soil, which, in the common course of cultivation can never become greatly impoverished; and even in the absence of all manuring, must long yield a profitable return to industry judiciously applied.

The rock formations throughout the district retain their original and nearly horizontal position, undisturbed since their deposition by any apparent violent elevating or upheaving force; and, on examination, exhibit a continuity easily traceable in every portion of it. Yet that such forces have at one period operated with considerable intensity, is evident from the present configuration of the surface. The deposites have all, to a greater or less extent, been fractured, and in directions usually corresponding with the cardinal points; and the fissures thus created have manifestly determined the course of ravines and channels of water courses.

Every portion of the district exhibits evidence of long continued abrasion and denudation. The immensity of the change thus wrought, is most strikingly demonstrated upon examination of the present condition, form, and structure of the principal mounds. These ancient land-marks of the olden world are the most prominent and picturesque objects in the scenery of the state—monuments of ages of change and revolution anterior to the creation of existing organisms—and which, from some peculiarity of texture and composition, or from having been original centres of elevation, have withstood the ravages of time and tempests, while surrounding rocks have crumbled to dust, and their materials been removed to distant and lower levels.

The height of these mounds varies from six to twelve hundred feet above the level of the Mississippi river. On ascending them the several strata found, lie above, and differ essentially from, the common surface rock of the district; and, at about corresponding levels, are identical in color and texture, order of superposition, chemical composition, and fossil contents. Although now so widely detached and apparently isolated, this arrangement of strata furnishes undoubted evidence of their former continuity over all the intervening country; and, as there has been no local elevation, the conclusion is inevitable that from three to five hundred feet in vertical depth of the former surface deposits have been broken up and carried away. Had it not been for such immense changes, or had the drift formation so widely diffused elsewhere over the state, covered the district, the metalliferous treasures of the lower formations must have ever remained hidden or to a great extent unavailable.

Extended and magnificent views of the scenery of the southwest may be had from the summits of all these elevations, as each one overlooks a large district of country. The western peak of the Blue Mounds, however, from its greater height, affords the most extended and complete prospect in the state, if not in the north-west. Standing on this point, over a thousand feet above the adjacent Wisconsin river, and five hundred above the general summit level of the surrounding country, a charming and diversified view of western scenery is spread out to the spectator, embracing, with a clear sky, an area exceeding one hundred miles in diameter. The boundaries of this view southward, are the high hills and bold peaks of Illinois; and farther west and low down upon the horizon, the ridges back of Galena, and Sherald's Mound in Iowa, about seventy miles distant. The view westward is bounded by the bold bluffs of the Mississippi, backed by the wooded heights of Iowa, extending northward full sixty miles.—North is seen the dividing ridge between the Kickapoo, Pine, and Baraboo rivers, Bear, Honey, and other creeks, and the valleys of the LaCrosse and Lemenwoir. And eastward the eye loses itself amidst forests and prairies stretching away to the limits of vision, and blending with the light haze and deep blue of the atmosphere.

The filling in of this immense picture is as gorgeous as the frame work is vast and magnificent. Radiating from the highlands, and traceable by lines of forest, are seen the valleys of Sugar River, the Pecatonica, Galena, Platte, Grant, Blue, and Wisconsin rivers, as also those of the Wyoming, Otter, Blue Mounds, and Black Earth creeks. The three Platte Mounds, although near forty miles distant, appear as near neighbors in the landscape—while Sinsinawa, some thirty miles further, marks the south-western limits of the state. Bold and rugged highlands, and deep, dark gorges define the valleys of streams flowing from the southward into the Wisconsin; and numberless dells and jagged peaks mark the embouchures of streams coming in from the north. The bluffs of the Baraboo, six hundred and ninety feet in height, stand out in relief against a back ground of forest and prairie, presenting a peculiarly rugged and picturesque landscape. Innumerable groves dot the surface of the prairies which in the summer season appear like seas of waving grass—sometimes in long and wavy lines—now dark and dense—now light and fleecy, through the distant openings of which appear the dim outlines of villages, or the light smoke of the lead furnace. But all mere description is tame in comparison with the real beauty and grandeur of such scenery.

The ascent to all the mounds is quite easy. An almost insensible rise of many miles terminates at the base, and though their sides are broken and abrupt, there is little practical difficulty in gaining their summits. They are usually covered with groves or thickets, which have gained a foot-hold since the commencement of settlements, and the suppression of the annual fires. The same remark is equally applicable to most of the timbered lands of the district. They have grown up within the memory of the earliest settlers; and, with proper caution, no reason exists why within a few years, it may not become a well timbered country.

Mining is at present the absorbing interest of the district; but agriculture is steadily gaining in importance. The uncertainties of mining throw a charm about it not possessed by other industrial pursuits. Perseverance and hope are essential to the successful prospector. Years of patient toil have to be balanced against the chance of sudden wealth. The work though severe, is not thought unhealthy, as custom limits the hours of labor below that of other pursuits. Taken as a whole, the occupation pays as well, and it may be better than other industrial avocations. It necessarily leads to habits of close observation, and the fact is now well understood that the discovery of large mineral deposites is not often a matter of chance—that the lodes have not an accidental arrangement, but have resulted from a law general in its operation, and which may in time be ascertained and comprehended.

There is no portion of the west more attractive than the mining country. In climate, health, and capacities for material profit, it is no where excelled. Its home markets have always been good, and it will soon enjoy the facilities of a ready and cheap transit for surplus productions. It is believed there is no exaggeration in the prediction that it is destined to become the wealthiest portion of the state.

Respectfully submitted,

H. A. TENNEY.

# APPENDIX.

# CIRCULAR OF THE STATE GEOLOGIST.

The following circular was issued soon after my appointment.—It has been responded to by many public spirited citizens, and I most earnestly entreat attention to the matter of which it treats:

## CIRCULAR OF THE STATE GEOLOGIST.

Fellow citizens:—Having been commissioned to execute the Geological survey recently authorized by the Legislature, I venture to invite your co-operation. The objects of this survey are to ascertain the character, position, thickness and horizontal extent of the various beds of rock, which occur in our State. To discover the location, quality, mode of occurrence, and amount of all valuable mineral substances; to analyze the soil in various localities with a view to test its agricultural capacities, and determine its proper uses, and the best means of improving it. And, in general terms, to collect and arrange, all knowledge that can be obtained of the physical resources of Wisconsin.

By this means, our own citizens, and the world at large will be furnished with reliable information concerning our natural endowments as a State. The dissemination of such knowledge will invite population, hasten the development of our known resources of wealth, and at the same time open up new mineral treasures, as yet undiscovered. In this way, every citizen is to be a sharer in the substantial benefits of the survey, and has a direct interest in its successful prosecution.

The sum of money appropriated to this work, though probably as large as the financial condition of a State so young as ours would warrant, is small when compared with the labor to be performed. This deficiency, however, must be balanced so far as possible, by judicious management, and such voluntary assistance as the intelligence and patriotism of the citizens at large may prompt them to render. With the limited means at our disposal, it rests with you, to a great extent, to decide how much shall be accomplished. To give a profitable direction to any co-operative efforts which may be made, I offer a few practical suggestions, of the highest importance to the interests which we propose to advance, by a Geological survey.

1st. Observe the character of the rocks, if any are exposed in your vicinity, whether they are arranged in layers, (stratified) or occur in irregular masses; (unstratified) whether they contain any curious petrifactions, or shapes of animals or plants in stone.

2d. If there are different beds of rock lying one above the other, as sandstone, limestone, &c., note their thickness, extent upon the surface, and order of superposition.

3d. In excavations for railroads, canals, sinking shafts for wells, mining, &c., preserve specimens of the rocks, clays, soils, &c., of every foot in depth, and take careful minutes in writing, of the order in which they occur.

4th. Collect specimens of all rocks, clays, marls, peats, and all soils remarkable either for productiv eness or sterility in your vicinity. These should be fair average specimens, and such as would afford by analysis, a test of the composition of the entire mass from which they are taken.

5th. Carefully preserve all petrifactions, and all bones, teeth, tusks, or other remains of animals found in the soils, clays, gravels or elsewhere.

6th. If beds of limestone, fit for marble; grindstone quarries; sand, which might be used for glass, &c.; clay for pottery; metallic ores; or any mineral substance, which in your opinion, might be valuable, occurs, collect and forward specimens of each kind.

7th. Where veins of ore are being worked, (in the "lead region particularly,) notice their length, direction, increase and diminution in thickness, as they traverse the rock, depth below the surface, and product of ore. Accurate drawings of particular veins which can be prepared easily by the practical miner, as he works them out, would be of great value.

8th. Note such facts as have, or may come under your observation, which seem to prove that lead has been formed at recent periods, and is still slowly accumulating.

9th. Will the owners of all works for the reduction of ores, furnish a statement of the amount of ore worked, costs and method of reduction, and pure metal produced within the year.

10th. In general, collect all specimens, and facts, which in your opinion will be interesting or useful to be generally known.

Specimens of rock or ores should be about 4 inches square.—Petrifactions should be sent whole, whatever may be their size; if broken in extracting from the rocks, carefully preserve the fragments. Soils may be put up in four ounce vials. Each specimen should be wrapped in paper by itself with a label, stating its precise locality, written with ink. When thus prepared, specimens may be forwarded in a box carefully packed, to the *State Geologist, Madison, in care of the Governor.* They may be sent by the member elect from each assembly district, who will no doubt see to their safe delivery as a matter of public interest, or forwarded by any other means which may be thought proper.

All communications may be directed to E. Daniels, *State Geologist, Madison,* where they will be sure to reach me at any time.

By following these suggestions, every citizen can render an essential service to the State, and promote the common interest of its people; and at the same time, be acquainting himself with important facts, and contributing to the advancement of sound science.

To the young men of the State, especially, would I appeal.—You have the will and energy, and power to do; you are to live, and take your part in the growing destinies of this young commonwealth. Give your aid then to the developement of her resources, and the advancement of her material prosperity. Seek out what provisions a bountiful Providence has made for you in her fertile soil, on her beautiful surface, and in the treasured depths of her generous bosom. Your patriotism can bring to her no more grateful offering; your energies can be enlisted in no nobler service. The field operations will occupy several months of the year, and will afford excellent opportunities for the instruction of such young men as may wish to learn the practical applications of science in this direction.

EDWARD DANIELS,
*State Geologist.*

MADISON, April, 20th 1853.

# GLOSSARY

## OF GEOLOGICAL AND SCIENTIFIC TERMS EMPLOYED IN THIS REPORT.

### A

*Anticlinal Axis.*—Where the strata dip in opposite directions, like the sides of a roof, the line towards which they rise is called an anticlinal axis.

*Arenaceous.*—Sandy.

### B

*Boulders.*—Rocks which are often found in fragments lying upon the surface or loose in the soil, frequently rounded by attrition, and generally differing from the underlying beds. They have been transported from distant localities.

*Black Jack.*—Sulphuret of zinc.

*Breccia.*—A rock composed of angular fragments cemented together.

### C

*Conformable.*—When strata are arranged parallel to each other, like the leaves of a book, they are said to be conformable.

*Crop Out.*—The emergence of a rock at the surface, lying in place—as where the strata have been worn through by a stream, their edges will crop out upon either side of the valley.

*Crystalline.*—An assemblage of imperfectly defined crystals, like loaf sugar and white marble.

*Calcareous.*—Composed principally of lime.

*Coral.*—A hard calcareous secretion formed by certain marine animals.

*Champion Lode.*—The principal lode of a group of veins.

*Comb.*—The parallel arrangement of the ores and vein-stones in a lode.

*Cap, or Cap Rock.*—The layer of rock which covers an opening or expansion of the lead-bearing fissures.

*Cotemporaneous.*—Of the same age.

**D**

*Drift.*—Deposits of boulders, gravel and sand, which are found spread over the surface of the rocks, supposed to have been dispersed from the northward by the action of waves and icebergs.

*Dip.*—Where strata are not horizontal, the direction in which they sink is called the direction of their dip.

**F**

*Formation.*—A group of rocks having a common origin.

*Fossils.*—The remains of animals and plants found buried in the earth or enclosed in rocks. When the organic matter has been replaced by mineral substances, they are called petrifactions.

*Fossiliferous.*—Containing fossils.

*Float Mineral.*—A term used in the mines to describe the loose ore which has been left by the wearing away of the rocks.

*Fault.*—A dislocation of the strata, so that the layers of rock upon one side of a fissure have slidden past those corresponding to them on the other.

**G**

*Galena.*—An ore composed of lead and sulphur.

*Geology.*—A science which has for its object to investigate the structure of the earth, the materials of which it is composed, the order in which these are arranged, and the action of those great natural causes which have produced and are still producing changes upon its surface. Economical Geology applies those facts to the useful purposes of life.

*Granite.*—An unstratified rock composed principally of quartz, feld-spar and mica.

*Ground.*—In mining, the rock through which the veins are worked is called ground. Dead or barren ground is such as yields no ore upon working.

**H**

*Hornstone.*—A silicious mineral, resembling flint in its characters.

*Hade.*—The deviation of a descending vein from a perpendicular line, is called its hade or underline.

*Heave.*—See FAULT.

**I**

*Igneous.*—Formed by the action of fire.

**L**

*Laminæ.*—The thin layers into which strata are often divided.

*Loam.*—A mixture of sand and clay.

*Lode.*—A productive metalliferous vein.

### M

*Matrix.*—Those substances included within the walls of a metal-bearing fissure, and accompanying the ore, are called the matrix of the ore; sometimes, also, the gangue or vein-stones.

*Mammillary.*—Studded with small segments of spheres, like the swell of the breasts.

*Mineral.*—This term includes in its proper signification all substances which do not belong to the animal or vegetable kingdom—even air and water are minerals.

*Mineralogy.*The science which treats of the nature and classification of minerals.

*Mastodon.*—A class of extinct animals, allied to the elephant.

### N

*Nodule.*—A rounded irregular shaped lump or mass.

*Nucleaus.*—The central point around which the matter of a nodule is arranged.

### O

*Outlier.*—Hills or ridges of rock strata occurring some distance from the general mass of the formations to which they belong. They have been caused by the wearing away of the strata which once connected them with the main mass of the formation.

*Oxide.*—A combination of oxygen with another substance.

*Oolite.*—A rock composed of small rounded particles, resembling petrified fish spawn.

*Opening.*—The expansion of a crevice forming a cave; or a large extent of soft ground, often containing large quantities of ore.

### R

*Rock.*—All beds of mineral matter, whether of sand, clay, or firmly aggregated masses, are called rocks.

### S

*Shale.*—Hardened clay, usually divided into thin laminæ.

*Stalactite.*—A concreted deposit hanging from the roof of caves like an icicle.

*Stalagmite.*—Crusts formed by the dripping of water upon the floor of caves, which holds in solution some mineral substance. The stalactite and stalagmite are formed by the same process.

*Strata.*—Layers of rock parallel to each other.

*Shaft.*—A vertical excavation sunk upon a mineral vein for the purpose of reaching its ores or ventilating the mine.

*Segregation.*—The drawing together of scattered particles to form one mass.

*Strike.*—(Synonymous with the "line of bearing.") The direction in which the edges of the strata crop out.

*Stratification.*—An arrangement of rocks in parallel layers.

**T**

*Trap Rock.*—A variety of the igneous rocks often found in connection with mineral veins, and which has been thrown up from below in a melted state like lava. It is not found in the mines of the Lead District.

*Throw.*—Interruption in the usual course of a vein.

**V**

*Vein.*—The mineral contents of a vertical or inclined fissure.

*Vitreous.*—Resembling glass.

ANNUAL REPORT

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# GEOLOGICAL SURVEY

OF THE

# STATE OF WISCONSIN.

By JAMES G. PERCIVAL.

MADISON:
BERIAH BROWN, PRINTER.
1855.

# GEOLOGICAL REPORT.

To His Excellency, Wm. A. Barstow,

*Governor of the State of Wisconsin:*

In presenting this report on the Geology of Wisconsin, it is proper that I should state the circumstances under which the materials for it have been collected. On receiving my commission as State Geologist (Aug. 12, 1854,) I proceeded, agreeably to your instructions, to examine the mineral district, included in the south-western counties of the State. It was my intention, in this examination, to make a preliminary reconnoissance of the entire district, so as to enable me to present, in my first report, a general view of the arrangement, both as exhibited on the surface and in the interior. In previous examinations of the same kind, I had found the great advantage of such general views, in preparing for a more just appreciation of particular facts, and of their mutual relations. One of the most important objects of a Geological Survey, indeed the most important, is to determine the system of arrangement, and the principles connected therewith, which may serve as a guide through what would be otherwise an inextricable labyrinth. This cannot be done satisfactorily without a minute and thorough investigation of particulars, but this should be made throughout with a view to the entire arrangement, and for this purpose a preliminary reconnoissance is required. Although I lost no time in pursuing this object, yet I found it impossible to visit the entire district, this season, and November 23, I returned to Madison, and after a brief examination of the country between that place and

Janesville, in reference to the strata, I applied myself to the preparation of my report.

I have visited, during this season, all the considerable diggings from the south line of the State to a line drawn from east to west, north of Cassville, Beetown, Potosi, Platteville, Mineral Point, Yellow Stone, and Exeter, and from the Mississippi to the east part of Green county. Some of the less important diggings, within these limits, may have escaped my notice, but I have endeavored to make such an examination of those I have visited, as my limited time would allow. I have also employed, in preparing this report, such facts as I had collected the former year, in the employment of the American Mining Company (N. Y.,) in exploring different localities in the same district, and particularly in examining the different strata, in reference to the probable descent ot the mineral through them. On this point, of so much importance to the mining interest, I had then ascertained a series of facts, which seemed to prove that all the limestones, from the surface of the upper magnesian to a considerable depth, at least, in the lower magnesian, were good lead-bearing rocks. My researches, this year, have enabled me to add many convincing proofs to what I had before ascertained, the whole showing a regular descent of the mineral through all the rocks, within the limits above indicated, except the upper sandstone. I have had no opportunity, this season, of extending my researches in the lower magnesian, its outcrop occurring chiefly in the northern part of the district, which I have not yet visited. I had, the former year, also applied myself to the investigation of other points of much economical interest, and have made them, this season, leading objects in my survey. Such are the surface arrangement of the ranges, by which they are combined into different groups, which are themselves also arranged in connected series, showing a regular system of arrangement, apparently pervading the whole district, so far as I have yet examined it; the vein character of the different deposits of mineral, recognizable in all their varied modifications; and the different character of the openings in the different limestone strata, showing that while all of these are lead-bearing, yet that each presents some peculiarities in the arrangement and character of its mineral deposits. The facts, which I have thus far collected, on these points, appear not a little encouraging, as exhibiting regularity and order in arrangement, and striking analogies to the best mines in corresponding situations in Europe. The opportunities for examining the interior of mines, are not now as frequent as I could have wished, but I have improved every opportunity which has presented, and have been able, during the two seasons, to examine the interior of more than two hundred different mines, of varied extent from the smallest to the greatest.

From the short time that I have been employed by the State, it cannot be expected that I should prepare a complete report. In this, I have had in view the immediate interests of the mineral district, and I have endeavored to give it a practical bearing. My object has been to give general views of more immediate importance, and rather to point out the method I design to pursue than to give the results of a survey. Local details, and such as have no direct bearing on my present object, are reserved to another occasion.

I have confined myself, in preparing this report, chiefly to my own observations, and have proceeded no farther than the facts, which I have myself collected, would seem to warrant. Although I have not yet been able to explore the whole mineral district, and may therefore have failed to ascertain some facts, which may have an important bearing in determining the entire arrangement, yet I have felt warranted, from what I have already ascertained, in stating, with some confidence, the conclusions to which I have already alluded.

The mineral district is of such relative extent; its resources, mineral and agricultural, are so great, that whatever interests that must largely interest the whole State. The act, making the appropriation for this survey, requires that that district should be first surveyed; but occasional opportunities may, in the meanwhile, be taken to examine such other points as may be of immediate importance. The survey of the whole State must be the work of time; to be valuable, it should be made deliberately, and as far as possible, in a connected order. As long as I am entrusted with this object, I shall endeavor to give it such a direction, and particularly to make it contribute to develope the great resources of the State.

Herewith I have the honor of submitting the following report:

Very respectfully,

JAMES G. PERCIVAL,
State Geologist.

# REPORT.

The Mineral District in Wisconsin, so far as I have examined it, includes all that part of the State between the Mississippi, on the west, and the valley of Sugar river, on the east, south of the line already indicated. Small quantities of lead ore are reported to have been found farther east, between Sugar and Rock rivers, and even in the quarry at Janesville, on the east bank of Rock river. In general, the diggings are more frequent and more extensive towards the west, and become more detached and lighter towards the east, but with some important exceptions. These will be noticed, hereafter, more in detail.

## STRATIFICATION.

The rocks, in this district, form a series of strata, overlying each other nearly horizontally, already noticed in preceding reports. In describing them, I shall point out such characters and distinctions as I have myself observed, and which have appeared of practical importance. It has been noticed in other mining countries, that different rocks have different relations to particular minerals; that a given metallic vein, in one stratum, will yield more abundantly than in another, and will present peculiar characters in traversing each stratum. Such appears to be the case in this mineral district, and it hence becomes important to mark, as far as possible, all the different modifications in the strata.

The surface of the mineral district may be regarded in general as a plain, traversed in different directions by valleys and ravines, radiating from the principal water-courses. Seen from a distance, these are less obvious, the higher points of the surface, themselves on nearly a common level, commanding the view, and giving to the whole the appearance of a vast plain. Above this plain rise a number of elevations, called mounds; some isolated, such as the Blue Mounds, the Platte Mounds, and the Sinsinawa Mound, in Wisconsin, and others forming connected chains of highlands, such as the range east of Galena, in Illinois, and the Highlands along the west side of the Mississippi, in Iowa. These mounds are composed of strata, overlying the strata occupying the general plain.

The strata, in this district, appear nearly horizontal, but have slight dips in different directions. A general dip to the west of south has been recognized in former reports. A general dip to the south appears obvious, even if the part of the district examined by me be alone considered. Such a dip to the south would, in a general plane surface, bring the lower strata to that surface successively towards the north, and such, in the whole, appears to be the fact in this district. A general dip to the west has appeared to me less obvious, though favored by many facts, particularly the great extent of the mound rocks in the Highlands of Iowa, and the greater thickness of the upper strata generally towards the west.

Besides this general dip, local inequalities in the stratification may be observed at various points, indicating extraordinary elevations of the strata at those points. These appear to be rather detached elevations at different centres, than along extended lines of anticlinal axes. They occur generally in connexion with the deeper valleys, where there has been a considerable degree of denudation, and at such points the lower strata are brought to the surface at extraordinary elevations, and exhibit striking inequalities within short distances. Such points of elevation may be observed on Fever (Galena) river, between Benton and Shullsburg; on the West Pecatonica, near Mineral Point; on the East Pecatonica, near Argyle; on the waters of Sugar river, near the line of Dane and Green counties, and on the Platte river, between Platteville and Potosi. From these centres of elevation the strata dip in different directions, by which the higher strata are found successively overlying the lower on the north as well as on the south. Thus the extraordinary dip to the north from the centre of elevation on Fever river presents the overlying strata on the surface to the north of the outcrop of the lower strata, and has given place for the occurrence of the mound strata at the Platte Mounds. In the same manner, there is at Dodgeville, though six to seven miles north of Mineral Point, a greater thickness of strata than at the latter, near which the lower magnesian is even brought to view.—The details respecting these elevations will be given after the description of the different strata.

The series of strata, which I have had an opportunity of examining, may be thus arranged. 1. The Mound Strata, consisting of three distinct beds of limestone; the upper, middle and lower. 2. A bed of Blue Shale, separating the mound strata from the next lower limestone series. 3. The Upper Magnesian of Owen, also consisting of three distinct beds. 4. The Blue Limestone, including the Blue and the Buff Limestones of Owen (1st Rep.,) also presenting three distinct beds. 5. The Upper Sandstone. 6. The Lower Magnesian of Owen. This last I have not yet had an opportunity of examining through its whole depth, but I have observed, in its upper portion, two distinct beds, well characterized. 7. The Lower Sandstone. This I have not yet had an opportunity of examining in connexion. The arrangement of each of the limestone series, at least of the three upper, in three distinct beds, is worthy of attention. Other minor distinctions may be noticed, and have in different places attracted the attention of miners, as of practical importance. These I have endeavored to ascertain, and shall mention, so far as I have been able to determine them; but from their nature, they can be fully determined only by a more complete survey than I have yet made.

## MOUND STRATA.

The Mound Strata, within the limits of the mineral district in Wisconsin, occupy only a few detached points, considerably elevated above the general surface. These are: the Sinsinawa Mound, a detached summit near the south line of the State and on the limit of the towns of Hazel Green and Jamestown; the Platte Mounds, two detached summits, one east, the other west of Belmont, with a smaller elevation of the same character between them; the Blue Mounds, two summits forming part of a connected range, near the line of Dane and Iowa counties; and the north-east point of a range of mounds, extending from near Galena towards Shullsburg.

The three distinct beds, above mentioned, are most complete in the southern mounds, and are apparently partly denuded in the northern. They may all be distinguished in the Sinsinawa Mound, but the upper appears there less complete than in the Table Mound, an outlier of the Highlands, south-west of Dubuque. The entire series is composed chiefly of a thick-bedded limestone, fine-grained and nearly white, when unstained, and well adapted for building. The upper bed is characterized by a great abundance of corals, of which the *Catenipora** is the most distinctive. The middle bed abounds more or less in hornstone (flint,) arranged conformably to the stratification. This, in the southern mounds, is less abundant, and more in detached nodules, while in the northern mounds, it is more abundant, and even, in the Blue Mounds, almost replaces the limestone. In the northern mounds particularly, it is distinguished by a reddish-brown colour. It may thus have given origin to the layer of red flint in clay, which immediately overlies the rock on the general surface throughout the mineral district. The lower bed contains little flint, and is less abundant in fossils, particularly corals, than the upper, It appears, however, thicker bedded, and is more important for lime and building. The mound limestone has never been found to contain any considerable deposit of lead ore. Traces of mineral are reported to have been found in it, and some fruitless excavations have been made, one of which I have examined on the top of the Sinsinawa Mound, but have observed there no appearance of lead ore.

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* *C. escharoides.*

### BLUE SHALE.

The Blue Shale, wherever I have had an opportunity of observing, underlies the limestone of the mounds, and separates it from the Upper Magnesian limestone. It is composed of a thin even argillaceous slate, quite hard in its natural state, but more or less subject to decomposition into a soft clay, sometimes retaining its original blue color, but more usually stained yellow, and forming then what is called by the miners, a pipe clay. Its surface, from its tendency to decomposition, is always concealed by earth, unless exposed in ravines or by excavation. It extends to a greater or less distance around the mounds, and graduates by decomposition into the pipe clay, which overlies its undecomposed part, when thickest, and replaces it entirely on its outskirts. Thus at the Jamestown Mine, near the Sinsinawa Mound, it was found, in the engine shaft, immediately overlying the upper magnesian, unchanged, and itself overlaid by the pipe clay, while in shafts more remote from the mound, it was found entirely converted into the pipe clay. This bed is less open and pervious than the limestones, and consequently the water from the mounds issues in springs above it, marking the line of its upper surface.

The shale itself contains few, if any fossils, but at its junction with the upper magnesian, there is a very thin bed, (two to three inches thick,) composed almost entirely of very small fossils and concretions, usually firmly cemented by iron, and therefore called hard-pan by the miners, but sometimes softer and with a more calcareous cement. Usually one or more thinner layers (about one inch thick) of the same character are found interposed in the blue shale, within the first 2—4 feet above the upper magnesian. These fossiliferous and concretionary layers are important as serving to determine the formation of the pipe clay, overlying the upper magnesian, from the blue shale. In the shafts, at the Jamestown Mine, where the pipe clay immediately overlies the upper magnesian, these layers are found precisely of the same character and in the same position, as where the unaltered blue shale meets the same rock. In different places on the higher points, where the upper magnesian is most complete, that rock is found overlaid by pipe clay, in which the same fossiliferous and concretionary layers are found, in the same position as I have already stated. This I have observed very perfectly at the Muddy Diggings, on high ground, north of Cassville, at the distance of several miles from the mound rocks; the nearest position of these being in the Highlands of Iowa, beyond the Mississippi. In other places, the peculiar fossils and concretions of these layers are observed on the surface of the upper magnesian, where the pipe clay is less obvious. This I have noticed in different places on the higher grounds in Hazel Green, six miles from the Sinsinawa Mound, and still farther from any other locality of the mound strata. These facts seem to indicate a former general extension at least of the blue shale, over the surface of the upper magnesian.

## UPPER MAGNESIAN.

The Upper Magnesian* consists of a series of limestone beds, of great thickness, in which the greater part of the lead ore, raised in the mineral district, has been found, and from that circumstance, it has been sometimes called the mineral rock. But the other beds of limestone, underlying it, (the blue limestone and the lower magnesian,) have been found to be good lead-bearing rocks, and consequently this latter term can no longer be regarded as distinctive. The prevailing character of the rock in this series, is that of a light grey thick-bedded limestone; sometimes uniformly fine-grained and even compact, but more often partly fine-grained and compact, and partly coarser grained and more distinctly crystalline, or even with small geodic cavities. This latter structure occurs more particularly in connexion with mineral deposits, or in what is called the opening rock. In such instances, either the compact or the more crystalline portion may be the ground, through which the other is disseminated; the former as nodules or concretions; the latter as geodes or approaching such.

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* This term, introduced by Owen in his first report, has been generally adopted in the mineral district, and for that reason I have preferred to retain it.

The rock of this series is generally more or less subject to decomposition, and the coarser grained portions most so, which often gives to it a peculiar cavernous character. This circumstance renders it less valuable for building, although occasionally fine-grained or compact beds occur of superior quality for that purpose. The quarry from which the Catholic Church at Benton has been erected is one of that character. This rock too, in the openings, is often found decomposed in part to a fine sand, retaining its structure unchanged, in which the harder compact concretions lie loose in their original position, and are called tumbling rock by the miners. It has been called, from this circumstance, sand-stone and sand-rock, by the miners, but as these names are liable to confound it with the proper silicious sandstone, they should be rejected.

There is generally a thin bed of a thinly schistose subargillaceous limestone at the upper surface of the upper magnesian, called shingle rock by some miners. Layers of shale occur occasionally through the whole extent of the series; sometimes distinct; sometimes firmly attached as a coating to the layers of the limestone. The original color of these is generally blue, but they are often stained green or yellow. They are usually found decomposed to clay in the openings, and are then called, in some places, clay randoms, and are regarded as useful guides in determining the position of the miner. In the lower bed of this rock, layers occur of a very thin black or dark brown shale, more or less bituminous, accompanying particularly the green and brown rock openings at Mineral Point and between Benton and Shullsburg. Thin fossiliferous layers are also met with throughout the series, but most frequently in the lower part. The thicker bedded rock usually contains but very few fossils, and those of large size comparatively, while the thin fossiliferous layers abound in them, and those of small size and usually delicate texture. Some layers are found chiefly composed of minute fossils and concretions. The distinctive fossil of the entire series is the coral, called honey-comb or sun-flower, (*Coscinopora.*) I have observed it in all the beds of this series, but in none of the other limestones.

The upper bed of this series contains few or no flints, and is usually much thicker than either of the lower beds, and indeed, where it has suffered no denudation, is at least equal in thickness to the two lower combined. The middle bed abounds in flints, arranged in regular layers of nodules, usually white or light grey, but sometimes dark grey or black. The lower bed usually contains but few flints, but these are sometimes more abundant, particularly in the openings.

The character of the lower bed has not appeared as uniform as that of the two higher beds. Like the upper bed, it sometimes is light grey or bluish and compact, and is then valuable for building, when not too much jointed; but it is more often much traversed by argillaceous seams, separating or marking the surface of the layers. This bed is farther characterized by two peculiar rocks, known as the brown or black rock and the green rock, which occupy corresponding positions, but are usually found in different sections of the mineral district. On the Mississippi and Fever river, the brown rock is generally found connected with the openings in the lower bed, and contains more or less calcareous spar (*tiff*) disseminated through it. The green rock is found in a similar position in the northern and north-eastern diggings. The original color of these rocks is bluish, but they have derived their present tint from the decomposition of iron pyrites disseminated through them. The brown rock is of a more or less deep red brown color, usually pervading it uniformly, and from its peculiar tint, was called the chocolate-brown rock by Locke (Owen's 1st Rep.) The green rock is usually less uniformly stained, sometimes only on its seams, and apparently derives its color from the green hydrate of iron. Thin layers often occur in this bed, composed chiefly of flattened fucoidal concretions, but rarely containing any fossils. Similar layers are occasionally found in the higher beds.

Bars of a hard blue limestone often traverse the upper magnesian, in its different portions, more usually in a horizontal position, like beds, but sometimes in a vertical position, like veins. They are more or less intersected by iron pyrites, and are apparently connected with mineral deposits, to which they have an important relation. They often interrupt the progress of mineral veins, and are then said, by the miners, to cut off the mineral; whence the opinion has prevailed that the blue limestone cuts off the mineral, an opinion erroneously transferred to the blue limestone of Owen, to which it has properly no reference. This subject will be farther discussed in connexion with that of mineral deposits and veins.

## BLUE LIMESTONE.

The Blue Limestone series includes the blue limestone and the buff limestone of Owen's first report. These both evidently belong to the same series; the first including the two upper beds, the second the lower bed, already indicated. The three beds, of which the series is composed, are of nearly equal thickness.

The upper bed is chiefly composed of thinner more fossiliferous layers, between which are interposed some thicker and less fossiliferous. Some of the layers are almost entirely composed of fossils, and in some instances are subject to decomposition, leaving the fossils loose and entire. Thin layers of bluish shale alternate with the layers of limestone, and are often found decomposed to a soft clay, usually stained yellow or green, particularly in the openings. The layers of limestone are marked by a peculiar parallel or laminated structure, distinct from that of the upper magnesian, and are partly light grey and compact, furnishing the best lime, and partly blue and more distinctly parallel in their structure, and apparently subargillaceous. Some of the latter kind have been found to furnish a good hydraulic cement. This bed is usually overlaid by a bed of brown rock, in thin layers, and breaking in small jointed fragments, with more or less calcareous spar disseminated, but with few or no fossils. It is interposed, in the northern districts, between the green rock and the blue limestone, and may be considered as the lowest member of the upper magnesian. In some instances, a bed of blue shale, decomposing into a soft clay in the openings, is interposed between the upper magnesian and the blue limestone.

The middle bed of the blue limestone is composed of more uniform and thicker bedded very even layers, less abundant in fossils, but presenting some which have not occurred to me in the upper bed, such as trilobites, and the acorn (*Streptelasma.*) In the western districts, where most distinctly developed, this bed may be divided into three distinct portions: an upper, of a very fine crystalline grain, and of a light grey color, subject to a brown stain in connection with openings; a middle, of a dark grey color, hard and compact, breaking with a smooth conchoidal fracture, and called glass rock, in most of the diggings where it occurs; and a lower, forming a transition to the lower bed, and consisting of alternations of grey compact and bluish parallel seams, firmly connected, the former resembling the glass rock, the latter the prevailing rock of the lower bed. This lower portion is more fossiliferous than the two others, particularly on the surfaces of its layers. This distinction is well marked in Quinby's quarry on the Shullsburg Branch, north of New Diggings. In the most eastern districts, yet examined, this distinction appears less marked, nearly the whole bed being composed of a uniform fine-grained light grey rock, resembling the upper portion. The glass rock is there hardly represented. Nodules of flint occasionally but rarely are found in this middle bed, particularly in its upper fine-grained portion.

The lower bed, corresponding to the buff limestone of Owen, consists chiefly of a thick-bedded even rock, marked by a distinct parallel arrangement, and composed in a great measure of flattened vermiform and fucoidal concretions, most strongly marked on the surfaces of the layers. That these are merely concretions and not organic, appears to me very evident. The same structure is equally remarkable in certain thin subargillaceous layers, observed in the upper magnesian, particularly in its lower bed. The same appearance is observable in the transition from the sandstones to the lower magnesian, particularly on the surface of the layers, where marked by argillaceous seams. It would seem to be common where-ever there is a combination of lime and alumine. This lower bed furnishes a brown lime, and in some portions of it, a good hydraulic cement, which alone indicates its subargillaceous character. The natural color of this bed is a light blue, but it is very much subject to stain, buff or yellow,* from disseminated iron pyrites. Indeed in some districts, particularly the eastern, the whole series is generally found, at least near the surface, of a yellow color, only a few portions retaining their original blue color. The rock of this lower bed is easily dressed, particularly the middle portion of it, and in some instances is capable of a fine polish, forming, by its concretionary structure, a beautifully clouded marble. Quinby's quarry, above noticed, furnishes fine specimens. The same bed, in the quarry at Monterey (Janesville,) has been used for that purpose, but its effect is injured by small geodic cavities. This lower bed contains comparatively few fossils, particularly in its middle portion. Trilobites have been found in it, as well as in the middle bed. At its junction with the upper sandstone, there is usually a transition from one rock to the other; a number of subsilicious and subargillaceous layers intervening, the former of which are more or less oolitic in their structure.

### UPPER SANDSTONE.

The Upper Sandstone forms a bed of a generally uniform character, and of no great thickness, composed usually of fine grains of quartzose sand, very slightly cemented, and consequently very little coherent, often in the interior in the state of loose sand. The surface is generally more or less indurated, but often this harder coat is of very little thickness. The natural color of this rock is white, but it is very subject to stain yellow, red, and sometimes green, from the decomposition of disseminated iron pyrites. These stains are most remarkable on the surface and near the seams, and particularly near the junction of the rock with the adjoining limestones. At the junction of this rock with the blue limestone above, it is usually coarser grained, and often contains concretions of quartz, sometimes geodic, which have been evidently formed by chemical action. In this position too, concretions of iron pyrites, or of hematite resulting from its decomposition, are frequent; the latter often including a portion of the pyrites unchanged. Small nodules or seams of hematite, sometimes with iron pyrites, occur also in this part, filled with grains of quartz of a hyalitic appearance. This layer, which has been apparently so subject to chemical action, is usually of a dark red brown, or of a deep green color, (the latter from the green hydrate of iron,) and occasionally the adjoining sandstone, to a considerable depth beneath, is more or less stained green from the same cause. This rock is usually too incoherent to answer well for building, although generally sufficiently fine grained and thick-bedded for that purpose. It furnishes, however, a superior sand for mortar, and sometimes so hardens by exposure, as to be useful for building. In some districts, particularly on some of the eastern branches of the East Pecatonica, near the line of Green and Lafayette counties, this rock is composed of thin nearly schistose layers, and its lower part is then more or less filled with minute white calcareous grains, giving it a firmer texture.

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* It has been called, from this circumstance, the buff limestone, but might, with more propriety, be called the blue and buff limestone.

### LOWER MAGNESIAN.

This rock I have not yet examined through its entire depth, having had an opportunity of viewing it only in its southern and eastern outcrops, on the Platte, Blue, Pecatonica and Sugar rivers, and in a ridge 2—3 miles S. W. of Madison. The greatest depth to which I have yet seen it exposed, is nearly 100 feet, on the Big Platte, in Ellenborough. A thickness of more than 200 feet has been given it, on the Mississippi, by Owen, in his reports.* Wherever I have seen it, this rock has presented peculiar external characters, by which it can be readily distinguished from the preceding limestones. Among the distinctive marks which I have observed, the most striking are a peculiar concretionary nodular structure, and the occurrence of geodes lined with minute crystals of quartz, and of layers of flint less interrupted and nodular than in the preceding limestones, either white and abounding in geodes of quartz, or striped red-brown and yellow, resembling a striped jasper, and then more rarely geodic. Fossils are very rare, nor have I yet observed them in this formation.

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* Two hundred and twenty-five feet. (Report 1852.)

Where I have had an opportunity of observing it continuously underlying the upper sandstone, on the Blue and Platte rivers, it has presented two distinct beds, an upper and a lower. The first is composed of a series of alternations of subargillaceous and subsilicious limestones, more or less decomposible, with occasional interposed layers or beds of a purer and harder limestone. The subargillaceous layers sometimes form a marly shale, decomposing into a soft clay, and the subsilicious layers have often a remarkable concretionary structure, and resemble, in their grain at least, the silicious limestone of Fontainebleau. Sometimes layers of nearly pure sandstone occur even in the lower part of this bed. Flints, such as I have described, occur in this bed, particularly in the purer limestone, and in connexion with openings; but they have appeared less abundant in this bed than in the lower. From the decomposible character of the greater part of this bed, its surface is generally covered with earth, forming a sloping declivity. The lower bed is composed of a hard and purer thick-bedded grey limestone, resembling in its external appearance the corresponding middle bed of the upper magnesian, but distinguished by its structure, and its peculiar flints already noticed. This lower bed has been seen by me only in its upper portion. It appears, both on the Blue and Platte rivers, only as a low bluff (10—20 feet high) sinking below the surface. From its character, and particularly the great abundance of flints, it is apparently the middle bed of the entire series; a lower bed underlying it, corresponding in some degree to the upper bed already described. This, however, I offer only as a conjecture.

## LOWER SANDSTONE.

This formation I have not yet had an opportunity of observing in immediate connexion with the overlying stratum (the Lower

Magnesian.) The sandstone in the quarries west of Madison, from which that town is supplied with its material for building, is quite different in its character from the upper sandstone, and is apparently less purely silicious, and consequently less incoherent in its texture. It is overlaid in the quarries, particularly in those on the south (Larkin's,) by subcalcareous and subargillaceous layers, resembling not a little those which occur at the junction of the upper sandstone and the lower magnesian. Concretions of a flinty quartz are found in some of these, resembling similar concretions in the latter situation. From these circumstances, I should rather regard the sandstone in those quarries as belonging to the Lower Sandstone. This is farther rendered probable by the occurrence of those quarries on the north of a ridge, extending along the south side of Dead Lake, occupied by the lower magnesian, while the country to the south of that ridge is occupied by the blue limestone and the underlying upper sandstone.

It is worthy of remark that each of the limestone series admits of a three-fold division, distinct in the three upper series, and at least probable in the lower magnesian. A general character, independent of its fossils, pervades the whole of each series, by which it may be distinguished from the others, while each subdivision or distinct bed has its own distinctive characters. The middle bed in each is distinguished by an abundance of flint or hornstone, arranged in layers conformable to the stratification, either in detached nodules, or more connected. This is less obvious in the middle bed of the blue limestone; still nodules of flint are there of occasional occurrence, particularly in the upper fine-grained portion.

Estimates of the thickness of the different strata have been given in former reports; but such can be considered only as approximative, the strata apparently varying considerably in thickness in different localities. It may be considered a moderate estimate to reckon the thickness of the Upper Magnesian at 240 feet (120 feet for the upper, and 60 feet for each of the lower beds;) that of the

Blue Limestone and Upper Sandstone each at 60 feet; and that of the Lower Magnesian at 220 feet.

## EXTENT OF THE STRATA ON THE SURFACE.

The extent of the mound strata has already been indicated. The mound limestone is immediately confined to the mounds themselves. The underlying blue shale extends but to a limited distance around the mounds, although traces of the pipe clay, formed from its decomposition, have been found in different places very remote from them, as already stated. The upper magnesian occupies the remaining surface of the mineral district, so far as I have examined it, from the Mississippi to the valley of Sugar river, except at the points of extraordinary elevation already indicated. Viewing the surface of the mineral district as a general level, the upper magnesian has been subject to denudation by the general rise of the strata towards the north, and by the extraordinary elevations above referred to. The valleys and ravines have farther caused a removal of the upper strata, and an exposure of the lower, and this to a greater degree towards the north, and at the points of extraordinary elevation. The rock occupying the surface is thus subject to frequent variation, and can only be determined exactly by long continued observation. I can only, at present, make some more general statements, leaving the particular determination to a farther opportunity. This is, however, a a question of no little practical importance in mining. By determining precisely the stratum occupying the surface at any given point, the miner will know what depth ot mineral-bearing rock he may there expect; how many openings and of what character he may reasonably expect to meet. Where the whole thickness of the upper magnesian is known to be present, and this can be very satisfactorily determined by the occurrence of a bed of pipe clay with the accompanying fossil layers at its junction with the upper magnesian, and hardly less so by an abundance of the fossils of those layers lying loose on the surface of that rock, the extent of mining ground, other things equal, is of course greatest, and this will be diminished in proportion to the number of beds which are found to be denuded. Still where a great amount of the upper beds has been removed, particular localities, from the great richness of the deposits in the strata remaining, have been among the most productive in the district. Mineral Point is a remarkable instance of this, where most of the mining has been in the lower part of the upper magnesian, and in the blue limestone.

The effects resulting from the general rise to the north are so much involved with those caused by the extraordinary elevations that the subject will be best presented by first detailing the latter. The first of these elevations, which I shall notice, is that along Fever (Galena) river. The point of greatest elevation is on that river, about three miles north of Benton, and about E. S. E. of Buzzard's Roost (Meeker's Grove,) where the upper sandstone rises about twenty feet above the surface of the river. In the ravine descending north from Meeker's Grove to that river, the blue limestone is elevated at least thirty feet above the bottom of the ravine, on its east side, while immediately on the west side of the ravine, the brown rock (lower bed of the upper magnesian) sinks below the bottom, the strata on both sides remaining nearly horizontal; thus indicating a fault at that point. Proceeding north from that point, the lower strata soon disappear, and the different beds of the upper magnesian successively occupy the surface; first, the lower bed (brown rock;) then the middle flint bed (at Elk Grove village and the Strawberry Diggings;) then the upper bed (at the North Elk Grove Diggings,) and this continues to the base of the Platte Mounds, where it is overlaid by the blue shale and the mound limestone. Proceeding south from the point of greatest elevation, the sandstone soon disappears, but the blue limestone is exposed generally in the bluffs of Fever river, to a point about two miles south of New Diggings. It does not, however, sink uniformly towards the south, but presents a series of undulations, rising and falling, and that sometimes quite abruptly; but no other instance clearly indicating a fault has yet occurred to me. The blue limestone sometimes appears more elevated on one side of the valley than on the opposite side, but this may have been the result of undulation merely. It also appears along the branches of the river to a greater or less distance from their junction, particularly along the Shullsburg branch, where the same undulations occur as on Fever river. The blue limestone, in its progress south, apparently sinks below the level of Fever river, but again rises, at least twenty feet above its level, at Buncomb, and farther south, alternately sinks below and rises a few feet above the river, to its last appearance near the Galena and Chicago road. There would seem, in this instance, to have been an extraordinary elevation at the point near Meeker's Grove, above mentioned, causing a fault, with a gradual subsidence to the South, modified however by local elevations in its progress. This elevation would seem to have acted along the valley of Fever river, as an axis, throwing up the strata on each side. Thus the higher grounds, for about three miles south of Meeker's Grove, immedilately adjoining Fever river on the west, and in the point between that river and the Shullsburg branch, are chiefly occupied by the lower bed of the upper magnesian, and the diggings are there mostly in that bed. Farther south, the higher beds of that rock approach the river, but the diggings there, near the river, are in the flint or lower bed, chiefly in the former, and those in the upper bed only occur in the highest grounds, more remote from the river.

The next point of extraordinary elevation is that along the West Pecatonica, near Mineral Point. The highest point of elevation is apparently in the fork of the Pecatonica and Pedlar's creek, north of the Mineral Point and Platteville road. The lower magnesian there rises above the level of the river, presenting low bluffs (10—12 feet high) along its banks. Its exact junction with the upper sandstone is there concealed; a considerable interval, corresponding to its upper portion, intervening. From that point the strata sink to the north, as well as to the south. The sandstone, towards the south, sinks to the level of the Pecatonica, not far south of Bonner's branch. The bluffs of the same rock obviously decline towards the north, but I have not traced them far in that direction. There are, in this district, the same appearances of sudden local elevation as in the preceding. Thus on the east side of the Pecatonica, opposite Bonner's branch, the sandstone rises but a few feet (5—6) above the river bottoms, while not more than two miles farther north, it occupies two thirds the hight of a bluff, about 60 feet high, overlaid by the blue limestone. At Mineral Point village, the blue limestone rises high on the sides of the ridges, leaving only a moderate thickness of the flint bed at their summits, while the mineral openings are principally in the lower bed of the upper magnesian, and in the blue limestone. At the Dreadnought Mine, three miles north of the village, the main body of the flint bed is present, with its peculiar openings, and at Dodgeville, nearly eight miles north, a considerable portion of the upper bed of the upper magnesian is also present. At the Heathcock Mine (Linden,) six miles N. W. of Mineral Point, the blue limestone rises but a few feet (8—10) above the level of Pedlar's creek adjoining. These facts indicate a dip of the strata from the highest point of elevation towards the north. A similar dip is observable to the west, towards the Platte Mounds, and to the east, towards the high prairie ridge, separating the east and west branches of the Pecatonica.

Another point of elevation occurs on the East Pecatonica, at or near Argyle. At that point, there is an extensive basin, in which rise several low ridges, either composed entirely of sandstone, or of sandstone capped with the blue limestone. Different branches of the river here meet, from the north and the east, and along them lines of elevation may be traced, for several miles, in bluffs of sandstone, gradually sinking from the centre, but subject to local elevations, as in the preceding districts. This centre of elevation is bounded on the north by the high ridge extending west from the Blue Mounds, on the east by a range of high prairies extending south-east from the Blue Mounds towards Monroe, and on the west by the ridge separating the east and west branches of the Pecatonica.

Returning towards the west, another point of elevation occurs on the waters of the Platte, the centre of which is apparently on the Big Platte at Bald Bluff in Ellenborough, where the lower magnesian rises nearly a hundred feet above the level of the river. The exact line of junction with the sandstone is there concealed by the earthy slope covering the upper bed of the lower magnesian. The next lower bed of that rock rises in a low bluff from the water's edge. In tracing down the Big Platte, the lower magnesian appears to rise about 30 feet above the river level at the Red Dog bluff, and not more than 10 to 12 feet at the ferry on the Galena and Potosi road. At the latter point, the sandstone forms a low ridge in the valley of the Platte, on the west. This is below the junction of the Big and Little Platte rivers, and in this vicinity, the different strata appear at a higher elevation on the west than on the east side of the river, the upper surface of the blue limestone, on the east, appearing but little higher than that of the sandstone on the west. This point of elevation is connected with that on the Mississippi, by which the sandstone is raised above the water level from Sinipee to some distance above Potosi, and the blue limestone, towards the south, to a point, on the east side, near Gregoire's Ferry (opposite Dubuque,) but on the west side, only to Eagle Point (above Dubuque;) the strata being there apparently most elevated on the east side of the river. On the north, I have not had an opportunity of tracing the limits of this centre of elevation. On the east, it extends to the vicinity of Platteville, and is limited by the country adjoining the Platte Mounds, and on the south, it is confined by the high prairie between the Mississippi and Fever river, near the centre of which rises the Sinsinawa Mound.

Another centre of elevation apparently occurs on Grant river, south-east of Beetown, near the junction of Pigeon creek. At that point the sandstone is elevated 30—40 feet above the river, while lower down on the same river, at Waterloo, it is not exposed. The same is true on Rattlesnake creek, towards the west, and on the Beetown branch, towards the northwest; only the blue limestone appearing there at the surface. On Boyce's creek, south-east, towards Potosi, the blue limestone appears more elevated than in the vicinity of Potosi, as if within the limits of this centre of elevation. These limits are apparently the ridge of Boyce's prairie on the east, the high ridge between Grant river and Cassville on the south-west, and Blake's prairie on the north-west.

The excavations in the mines, in the vicinity of these extraordinary outcrops of the lower strata, are a farther proof of sudden elevations of the strata; the shafts being often sunk in the upper strata to a greater depth than would be sufficient to reach the lower, if the range of the latter from their outcrop was horizontal.

From the details of the above arrangement, some idea may be formed of the manner in which the different strata occupy the surface in the mineral district. On the higher portion of the ridges and prairies bounding the centres of elevation, the upper bed of the upper magnesian occupies the surface; most so towards the south, conformably with the general dip to the south. On some of the higher points, even remains of the pipe clay, with its fossiliferous layers, are observable, as already stated. These I have observed most distinctly at different points on the high prairie between the Mississippi and Fever river, both in Wisconsin and Illinois; on the higher grounds at the Blackleg Diggings, on the line of the two States; and on the high ridge east of the Mississippi, north of Cassville. Throughout these higher districts, the diggings are in the upper bed of the upper magnesian. On approaching the centres of elevation, or the general northern outcrop, a zone occurs, where the flint bed occupies the surface, sometimes quite narrow, and at other times, particularly in the forks of rivers, more extensive; the upper bed either thinning off gradually, or terminating more abruptly. In the former case, the diggings are often both in the upper and flint bed, near the outcrop of the latter. Still nearer the centres of elevation or the general northern outcrop, the lower bed of the upper magnesian occupies a similar zone of the surface, and here the same remarks are applicable as in the former instance. The blue limestone, and the strata underlying it, are generally exposed, in those centres, only along the sides of valleys and ravines, and rarely occupy any extent of surface. It would require long continued observation to collect the facts necessary for a map exactly exhibiting the extent of the different strata occupying the surface. Such a map would be very useful, not only in determining the mineral value of property to some extent, but also the probable character of soils, from the underlying rock.

In the north-eastern part of the country examined by me, along the valley of Sugar river, and west of Rock river between Madison and Janesville (south of the outcrop of the lower magnesian,) there has been obviously an extensive removal of the upper strata, but not accompanied, as far as I have observed, with such remarkable evidences of local elevation as in the mineral district. In the valley of the west fork of Sugar river, south east of the Blue Mounds (in the town of Primrose,) the lower magnesian rises, however, near 30 feet above the bottom of the valley, while the surrounding high prairie ridges are covered by the upper bed of the upper magnesian. From the valley of Sugar river, north east of Exeter, to Rock river, north of Janesville, I have observed no appearance of the upper magnesian. It may occupy the surface of the high prairie, extending west from Rock river, at and south of Janesville, but I have not yet had an opportunity of determining it. It however occupies the surface farther west, at least to the east of Monroe. The country north of that prairie, to within 5—6 miles of Madison, is traversed by numerous ridges, more or less isolated, with intervening basins; the higher ridges, so far as I have examined them, overlaid or capped by the blue limestone, and underlaid by the upper sandstone; the lower swells sometimes formed entirely of the upper sandstone. I have observed the lower magnesian in only one instance in this district, where it was reached in an excavation for a well, at sixteen feet, in the plain on the east side of Sugar river, near the foot of an isolated tabular ridge, formed of the upper sandstone overlaid by the blue limestone. The blue limestone, in this district, sometimes presents all its beds distinctly, as in Donaldson's quarry, near Stoner's prairie, south-west of Madison, and in the Monterey quarry at Janesville, and sometimes only the middle and lower beds, or the lower bed only, according to the degree of denudation. In this district, the middle bed of the blue limestone has presented only a uniform fine-grained rock, resembling the upper portion of that bed in the mineral district. The compact glass rock has not occurred distinctly. Along the northern border of this district of the blue limestone and upper sandstone, extends a narrow ridge, occupied by the lower magnesian, presenting the peculiar characters of its middle bed, as observed in the mineral district. This ridge ranges E. S. E. along the south side of Dead Lake, and in an E. S. E. direction, by the map, from the Wisconsin near Arena. The sandstone quarries, west of Madison, lie 2—3 miles north of it, in a parallel range, as if in the position of the lower sandstone.

I have made these statements in order to correct an error in former reports, which presents a singular anomaly in the outcrop of the strata, and might lead to embarrassment, particularly in examining the eastern border of the mineral district. It has been stated by Mr. Lapham, in a communication in Foster and Whitney's Report (P. II, 1851, p. 169,) that the limestone at Janesville is the lower magnesian, underlaid by the lower sandstone. This has been adopted by Owen, in the map accompanying his last Report (1852,) in which the outcrop of the lower magnesian is drawn from a point near the Wisconsin river, north of the Blue Mounds, along the east side of Sugar river, south east to Janesville. The limestone at Janesville is clearly the blue limestone, presenting its three beds with their distinctive characters and their peculiar fossils. The underlying sandstone has as strictly the characters of the upper sandstone, particularly at its junction with the blue limestone. The same is true at Donaldson's quarry, where all the beds of the blue limestone are present, well characterized, and the sandstone underlying that and the other more northern localities of the blue limestone is equally marked as the upper sandstone.

## SURFACE DEPOSITS.

The rocks, in the mineral district, are overlaid by a deposit of earthy materials of greater or less thickness, in some places to a depth of more than thirty feet. This consists generally of a strong clayey loam, called surface clay, of a light brown color, forming a subsoil at once free and retentive, and itself fertile. Formed apparently by subsidence from still water, from the decomposition of the upper rocks of the district, in which limestones, alternating more or less with shales, predominated, it has at once the characters of a calcareous and argillaceous soil, mixed with sufficient silicious matter to render it easy of tillage. It is only in very wet seasons that its adhesive quality is found inconvenient. In dry seasons, when other parts of the country, where the soil is lighter or more entirely clayey, have suffered from drought, this district has not been affected by it, and has yielded abundantly. It thus offers the rare combination of agricultural capabilities of the first order, united with mineral resources fully equal. Wherever the limestones form the surface rock, this clayey subsoil prevails. Where the upper sandstone is brought to the surface, there is a greater predominance of silicious matter; but this occurs to a small extent in the mineral district. In the valley of Sugar river, and in the country extending east from that to Rock river, north of the parallel of Janesville, where the upper sandstone is exposed to a larger extent, more sandy soils are frequent, but still fertile, and wherever the blue limestone extends in the swells and ridges, more loamy soils are observable.

Beneath the brown surface clay, there is usually found a layer of red clay, more or less filled with red or yellow flints, immediately overlying the rock, and often found extending to a greater or less depth into the open crevices. It is different from the clays occupying the openings and immediately investing the mineral, and has been apparently formed by subsidence, like the overlying surface clay.

The mineral district does not appear to have been invaded to any extent by the gravel and bowlder drift, which has covered so extensively other parts of the surface in this and the adjoining states. Apparently the bold escarpment, backed by the high ridges and prairies, along the south side of the Wisconsin river from a point not far east of the Blue Mounds, has obstructed the course of the drift current, and turned it east and south around the east point of the ridge at those mounds. An opening near the source of Sugar river seems to have given passage to that current, by which large accumulations of gravel drift have been formed along the west side of the valley of that river, near Exeter, and of bowlder and gravel drift farther east, while scattered bowlders, usually of no great size, are found in the side valleys, and on the slopes of the adjoining ridges and prairies, towards the west, as far south at least as the vicinity of Monroe. In the tract of country occupied by the blue limestone and upper sandstone, between the high prairie, west of Janesville, and the ridge of the lower magnesian, south of Madison, accumulations of such diluvial drift are comparatively small and unfrequent, but with occasional exceptions, while on the north of that ridge they are large and extensive; that ridge having also acted apparently as an obstruction to their progress. My observations in that part of the country, covered more or less by this diluvial drift, have been very limited, and a farther consideration of its extent must be deferred to a future occasion. The bowlders and smaller rock fragments, composing this drift, are chiefly derived from primary and trap rocks, though partly from the flints (hornstones and quartz) accompanying the limestones, particularly the lower magnesian. Small nodules of hematite, and of iron pyrites partly converted into hematite, such as occur at the junction of the blue limestone and upper sandstone, are frequently found in this drift and scattered on the adjoining surface.

In the immediate vicinity of the Mississippi, on the surface of the higher ridges and prairies adjacent, accumulations of drift are occasionally found, in some instances quite extensive, composed of a fine sand, usually yellow or light brown, as if formed from the sandstone adjoining that river towards the north. These are generally arranged in hillocks, with intervening round hollows or basins, such as are common in drift districts. This sand, on the surface, is mixed more or less with mould, forming a light soil, but at a small depth is sufficiently pure for mortar. A tract of 2—3 square miles, covered with such drift, and remarkable for its hillocks and hollows, extends from the bluffs of the Mississippi to the valley of the Great Menominee, S. W. of Jamestown village, and similar accumulations are met with on the high lands, adjoining the Mississippi, between Potosi and Cassville. On the summits of the river bluffs, particularly in the vicinity of Cassville, small rolled fragments of the same materials as those composing the gravel drift, above noticed, are often profusely scattered. These facts indicate the passage of a peculiar drift current along the course of the Mississippi, and it is worthy of remark, that the points where those accumulations are most remarkable are a little below two large bends in that river, namely, that from south tó southeast just above Cassville, and that to the south between Dubuque and Potosi. Such a deflection would naturally cause an eddy, and thus lead to those accumulations.

## MINERAL DEPOSITS.

The first object of the present survey is the investigation of the Lead Mines of the mineral district, and of the different useful minerals connected with them. The previous description of the strata is important, as fixing definite limits in mining, and from their peculiar connexions with the mineral deposits.

The metallic ores found in the mineral district are chiefly the sulphurets of lead, zinc, iron and copper. Other ores of these metals are also found, formed apparently by recomposition from the decomposed sulphurets. Such are the sulphate and carbonate of lead, the carbonate and silicate of zinc, the sulphate and hydrated oxyd of iron, and the carbonate of copper. The black oxyd of manganese also frequently accompanies the mineral deposits. Of these ores, the sulphuret of lead (galena) is the most important, and that which has been hitherto the sole object of mining in the mineral district, except in one instance (that of the copper, at Mineral Point.) I shall therefore make it the first object of my attention, and notice the others only as far as they have an immediate connexion with it. The term *mineral*, in the mining district, is restricted to the ores of lead, and without addition to the sulphuret, and is the term generally used there for the latter. I shall for convenience use it in that sense, in what follows.

The first subject to be considered, is the manner in which the mineral is deposited. It is a matter of great interest to determine, whether the mineral is arranged in continued veins, or in detached and casual deposits. The prospects of mining must be much greater, if the former arrangement prevails, than if the latter. During the whole course of my examination of the mines, I have made this a particular object of attention, and although interruptions in the deposit of the mineral are general, as I believe is the case in all veins, yet the characters of a vein arrangement have appeared every-where to predominate.

The mineral deposits, whatever may be their character, are usually arranged along continued lines, having a certain direction, thus forming ranges or leads (lodes.) These ranges are mostly combined, in a certain systematic order, into different groups, called diggings, between which there is a greater or less extent of country in which little or no mineral has been discovered. These groups are also connected, in a corresponding order, in more extensive series, showing the general prevalence of systematic arrangement. As little has been done in deep mining, and the deepest shafts yet sunk have been abandoned, I have had fewer opportunities than I could wish, of tracing the mineral, at the same point, through different strata. Still in several instances I have followed it without interruption, or with only such minor interruptions as are common in veins, through different strata. The mineral deposits exhibit too, in the different strata, peculiar arrangements, which are common to each throughout the mineral district, subject only to local modifications; thus showing the prevalence of arrangement in a vertical as well as horizontal order.

The ranges or leads have different directions, which preserve a great degree of regularity in the different groups or even more extended series. Three different classes of ranges are recognized, according to their direction, namely, East and West, North and South, and quartering; the last intermediate between the two former. Of these, the East and West are the most important, and apparently have had a leading influence in the arrangement. The term East and West is not limited to such as are due east and west, or nearly so, but in different groups is applied to the predominant ranges having a general east and west bearing, although in some instances they may deviate even 45° from a due east and west course. The term North and South is also applied to ranges which deviate considerably from a due north and south course, but rarely to those which deviate more than one sixteenth. Quartering ranges (called by the miners *swithers* and *contras*) include all such in a group as do not belong to either of the preceding divisions. They are such ranges as meet a leading range, particularly an East and West, at an oblique angle; consequently when the leading East and West ranges deviate from a due east and west course, a due East and West range would be considered quartering.

In general, the space in which the mineral is deposited, or through which it is distributed, if of much extent, is called an opening. This is sometimes filled with loose materials, and these by settling often leave a void between them and the roof, usually of no great extent; but in some instances larger cavities, or caves, have been so formed. In other instances, the opening is merely a certain extent of the rock, more or less modified, through which the mineral is distributed. Indeed, in nearly all those instances in which the openings are filled with loose materials, these appear obviously to have been derived from the decomposition of the rock, and not from materials deposited subsequently. Such openings differ from those in which the rock is only modified, by the greater degree of decomposition the rock has undergone. The rock immediately adjoining the openings is usually harder and more compact than the rock in general. That included in the openings is generally softer and more decomposed, and more or less stained with oxyd of iron. Different substances are also deposited in it, besides the mineral, such as other metallic ores, clay, calcareous spar and sulphate of barytes.* Openings, according to their direction and the manner in which the mineral is arranged in them, are vertical, flat (horizontal,) or pitching (oblique). The two first mark an important distinction in the arrangement in the different strata; the vertical openings predominating in the upper part of the upper magnesian; the flat openings in the middle and lower portions of the same, and in the blue limestone.

Although there are certain general principles which seem to have governed the arrangement of the mineral, yet numerous modifications occur, the details of which may be first given, before stating the former. In this detail, I shall commence with the arrangements observed in the upper part of the upper magnesian. The first and simplest form is that of the crevice. This may be either a joint in the rock, marked by an iron stain, or a fissure of little width, occupied by a seam of clay, or of ochre and iron rust (hematite); the two latter derived from the decomposition of iron pyrites, which sometimes, though rarely, is found in their place. Though the walls of the fissure are nearly parallel, yet it is usually marked by enlargements and contractions of little extent. In such a fissure, the mineral occurs as a sheet, either closely wedged in the rock, or separated from it by a thin seam of clay or iron. Such sheets usually conform on their surface to the adjoining substance, but occasionally present a more or less regular form, where the fissure is somewhat enlarged and the sheet is imbedded in clay. They are usually less interrupted than other forms of arrangement; in some instances, very little interrupted; in others, more so, when they are called broken sheets. When interrupted, they are replaced by clay or iron ore, and sometimes by calcareous spar, sulphate of barytes or zinc ore; but very rarely by the three latter in the upper part of the upper magnesian. Calcareous spar not unfrequently interrupts the vertical sheets in the lower part of that rock, and the mineral, when in contact with it, shows the same tendency to regular forms, as when imbedded in clay.* These sheets vary in thickness from a mere seam or film to a foot or more, and when even less than an inch in thickness, are generally profitable, from their little interruption, and when of great thickness, are, from the same circumstance, of extraordinary value. They may be either vertical, pitching or flat (horizontal;) but the flat sheets are rather parts of a more complex arrangement, while the vertical and pitching sheets may occur separately. These last are found with all the different bearings above specified; but the North and South sheets are the most common and the most important. Not unfrequently two or more sheets are connected; the rock between them being softer and more jointed, and forming properly an opening. In such instances, more clay and iron are usually present than where a single sheet only occurs. Such sheets often unite, in their course, in a single sheet, which again divides, or are connected by cross sheets, usually in a quartering direction. In such instances, there is generally an enlargement at the junction of the sheets, where the mineral often assumes its more regular forms, and even loses its sheet character, and takes that more peculiar to the wider openings.

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* Silex, in the form of quartz or otherwise segregated, except as flint, rarely accompanies the mineral, or is disseminated in the opening rock. In one of the North and Souths, at Skidmore's Diggings, a fine-grained silicious grit accompanied the sheet of mineral, as a matrix, arranged in sheet form between it and the rock; and in a brown rock opening, on the west side of Coon Branch, near Benton village, crystalline quartz was found disseminated through the opening rock, in place of the calcareous spar usually disseminated.

Vertical sheets have been sometimes worked to a great extent and with little interruption, vertically as well as horizontally, and have been traced through different beds in the same instance, and in different localities have been observed traversing some of all the limestone strata above the upper sandstone. I have observed such sheets followed to the depth of 80—90 feet through different beds of the upper magnesian, and at the lowest depth still continued, sometimes increasing in thickness. Others are reported to have been followed to the depth of considerably more than 100 feet and left still going down.*

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* The calcareous spar in such instances is sometimes distinctly crystallized, particularly in the form of dog-tooth spar.

When the crevice is of much width, and its walls are nearly parallel, it is called a crevice opening. The space, traversed by two or more connected sheets, might be called such; but the term is usually applied to an opening of a foot or more in width, in which the mineral occurs in some other form than that of a sheet. Such openings are nearly always quite vertical, but occasionally local pitches occur. The walls of such openings are rarely strictly parallel, but there is usually a series of enlargements and contractions. This tendency to enlargement and contraction is common, and is accompanied more or less by lateral cavities of different size and form. Indeed it may be said that those openings, which continue with little variation in width to a great extent, vertically or in the direction of their course, are one extreme, and that a series of isolated openings or cavities (called pockets,) connected by mineral seams, such as have been mentioned, are the other, between which almost every degree of alternate enlargement and contraction may be found. Openings are more rarely found of much extent vertically than in the direction of their course. Thus in sinking on a crevice, different openings will be found, one beneath another, little interrupted in the direction of their course, but generally separated from each other by close rock, traversed only by a mineral seam, yet occasionally connected in part by long narrow crevices, or by shorter and wider passages; the last sometimes rising to a greater or less height above the upper opening, and then called chimneys. In some instances, instead of this series of openings, one beneath the other, separated by close rock, there is only a series of enlargements, corresponding to the openings, separated by alternate contractions; the crevice remaining open throughout the descent. Different ranges in the same group occasionally differ in this respect; one being marked by distinct openings, and another adjacent, only by enlargements and contractions. Different ranges are also distinguished in the same manner, in the direction of their course; the openings in one presenting a series of isolated cavities or pockets, in that direction, separated by close rock, marked by a mineral seam, and in another, only alternate enlargements and contractions. Whenever, in such cases, the pockets or enlargements rise to a considerable height above the range of the opening, they are also called chimneys.

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* The largest North and South sheet at the East Blackleg Diggings is said to have been followed down to the depth of 140 feet, at the engine shaft, and left still going down, although with diminished thickness.

These are the most usual forms assumed by the vertical openings in the upper part of the upper magnesian. They commence at different depths in the rock, sometimes near or at its upper surface, sometimes at the depth of many feet. Where the whole thickness of the upper magnesian is present, together with the overlying blue shale or pipe clay, I have never seen the crevices or openings penetrate the latter, or even the thin bed of schistose limestone, called shingle rock, sometimes overlying the thicker layers of the upper magnesian. But often the crevice is struck immediately on entering the thicker layers of that rock, and the opening soon after, and in some instances, I have observed the openings rise to its upper surface, and immediately overlaid by the pipe clay or blue shale. Where these or the upper part of the upper magnesian have been denuded, such openings reach to the surface of the rock, and are called open crevices. More generally, although the crevice may at times be struck at little depth in the rock, the opening is not reached till at a greater depth, which in each group is usually common to all the ranges. This may be called the level of the openings, and it is at this depth, known by experience in the different localities, that openings are expected.*

The openings sometimes gradually expand from a narrow crevice, but more usually terminate above in a low arch, or are flat-roofed. The rock immediately above the opening is called the cap, and when one opening lies below another, the rock separating them is the cap of the lower. It has been already stated, that the rock immediately adjoining the openings is harder than the rock generally. This is particularly true of the cap, and when in sinking on a crevice, the rock becomes unusually hard, an opening is expected.

The openings, now under consideration, are usually filled with soft and loose materials, which seem to have been formed by the decomposition of the rock originally occupying them. These are usually what are called sand, clay and tumbling rock; the sand derived from the decomposition of the limestone; the clay, from that of shale or claystone; while the tumbling rock is but the harder and more compact portion of the limestone, which has resisted decomposition. In examining these materials, I have almost invariably found the sand and tumbling rock conforming distinctly, in their arrangement, to the stratification of the limestone, and the clay either arranged as distinctly in the same order, or appearing as an original matrix of the mineral.

I have already stated that the term opening is also applied to limited portions of the rock, less disintegrated, marked by certain peculiar characters, and traversed by the mineral, or through which it is disseminated. In such instances, other substances, besides the mineral, may traverse the rock, or be disseminated through it, such as other metallic ores, clay, calcareous spar and sulphate of barytes. Iron pyrites is always originally present in such portions of rock, and has generally suffered more or less decomposition, leading to the disintegration of the rock, and to the ferruginous stain common to all openings. The limestone, in such openings, even when least altered, appears to be made up of hard compact concretions, little or not at all subject to stain or disintegrate, imbedded in a ground of more granular structure, more or less subject to stain and disintegrate from disseminated pyrites. When this part of the rock is stained, as is usual, the rock of the opening has a peculiar mottled appearance, and is called calico rock, in some localities. This is peculiarly characteristic of the flat openings in the lower beds of the upper magnesian, particularly in the flint bed. In the vertical openings in the upper part of the upper magnesian, the tumbling rock corresponds to the harder unstained nodules or concretions in the calico rock, but usually of a much larger size, and the sand to the stained and softened ground of the latter.

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* The crevices are not only interrupted above by the blue shale and shingle rock, but often by many feet of the upper magnesian, and are sometimes struck only at a short distance above the opening. A mineral crevice usually first shows an iron stain on its walls, and lower down a seam of clay or hematite (iron rust,) and often still nearer the opening, a sheet of mineral, or detached pieces of the same in a sheet or vein position, leading to the opening. Often a seam of black ochre (oxyd of manganese) precedes the mineral, indicating its near approach, and the latter, when first met, is usually more or less coated with the carbonate. Not only is it common to find a seam of clay bordering sheets and veins, or otherwise investing the mineral as a matrix, but I have observed flat-roofed or low-arched vertical openings lined by a smooth unbroken seam of joint clay, more or less completely investing them, and yet the materials inclosed, except the mineral and its immediate matrix, arranged conformably to the stratification, and apparently altered or modified portions of the rock.

In the vertical openings in the upper part of the upper magnesian, the mineral, in general, is arranged vertically. In these openings, it shows a greater or less tendency to assume its regular cubic form. When its form is more regular, it is called square mineral; and when a number of cubes are combined, particularly in a sheet, it is called cog mineral. When its form is more irregular, showing only an approach to its regular cubic form, but in more or less detached masses, it is called chunk mineral.

The cubes or more irregular forms are arranged, in the vertical openings, in a certain order, more or less distinct, which may be called the *Vein order*. This is most distinct in the East and West ranges, but may be traced more or less even in the North and South sheets, where an approach to the cubic form is observable, and may be also recognized in the arrangement of the mineral in the flat openings. In this order, the cubes or masses deviate from a a direct line,alternately to the right and left, forming a zig-zag, but in such a manner as to continue the general direction. When a crevice is of little width, it is usually traversed by a single vein, or course of mineral in vein order, usually accompanied by clay as its matrix. But if this be examined strictly, it will be generally found double, or divided by a middle seam into two series of cubes or less regular forms, and the same is equally true of the sheets, which, as I have observed, occasionally in the wider parts of their crevices approach the regular form of the mineral. This too is often observed where the sheets are met by cross crevices. When a narrow crevice widens, the single vein divides, each of its symmetrical parts being continued along its wall, or sometimes only one of them, the other being interrupted. The surface of the mineral next the wall is then less regular, and conforms in general to the surface to which it adheres; that towards the middle of the crevice, which is usually occupied by clay, is more regular; the whole vein, in this instance, forming a more or less perfect geode. Where the crevice alternately widens and contracts, the same alternation will be observed in the arrangement of the vein. Such geodes or more irregular deposits, in the enlarged portions of the vein, are called bunches. In some veins there is a greater tendency to form bunches than in others, and in such cases the intervening portion of the vein is usually diminished or even interrupted. The arrangement of the vein thus corresponds to that of the openings.

Where the opening is wide, and includes considerable masses of tumbling rock, it may contain several such veins or courses of mineral, separated by the masses of rock, which may either unite, or be connected by smaller cross veins. Sometimes the wider vertical openings are traversed longitudinally, to a greater or less extent, by one or more vertical masses of rock, called key-rocks; but these rarely divide the openings completely, but are more or less insulated, corresponding to the horses of English miners. These are particularly connected with an important arrangement observed, in several instances, in the upper part of the upper magnesian. This occurs, when, in a wide opening, with a flat or slightly arched roof or cap, the lower part is chiefly occupied by one or more key-rocks, rising towards the roof; but leaving an interval of greater or less width above. Veins of mineral rise in the intervals between the walls and key-rocks, or between the key-rocks themselves, and pass over the top of the key-rocks in the manner of a flat sheet; the whole being thus connected. Some of the heaviest bodies of mineral have been found thus arranged. The lead struck about a year since, at Turner's Diggings, east of the Sinsinawa Mound, and one of the most productive for the time it has been worked, is of that kind. In some few instances, large bodies of mineral have been found on the surface of the rock, where it had suffered denudation, lying between two vertical veins in the rock; apparently resulting from such an arrangement. A remarkable instance of this kind occurred at Selkirk's Grove, west of Benton village, and a similar body of mineral was found in a ravine, near the lead at Turner's, lying on the surface of the rock, on one side of which at least a vertical vein was seen entering the latter.

An analogous arrangement is observed in the wide openings, called caves, remarkable instances of which occur in the Dubuque district. Veins rise there along the sides, and are continued upwards into the sides of the roof, and at the same time send flat sheets along the roof, the two from the opposite sides meeting at a middle crevice in the roof, and sending up through it a vertical vein, which often presents a geode as it enters the crevice, as if formed by the junction of the two. In one instance, where a cross section of the roof was exhibited, (at Stewart's cave,) the lateral vertical veins sent across other flat sheets through seams in the cap-rock to the middle vertical vein. The flat sheets, crossing under the roof and in the rock above, are generally thinner and more interrupted near the middle point between the side and middle vertical veins; a fact generally observable in flat sheets interposed between vertical veins, as if the formative action proceeded from the latter.

In some instances, in wide openings, where no key-rocks are present, an arrangement similar to that in the roof of Stewart's cave is observed in the soft ground of the opening itself; flat sheets not only extending across under the roof, but at intervals below; the opening being then occupied by decomposed rock, arranged conformably to the stratification. Sometimes the flat sheets extend only a short distance from the side veins, and in other instances, the side veins rise only partly towards the roof, and terminate in flat sheets extending but partly across the opening. In one instance, in such a wide opening (at the east end of Hughlett's lead, north of Galena,) a layer of hard rock was interposed in the soft ground in the lower part of the opening, as if dividing it into an upper and lower, below which a flat sheet extended across the opening, while the lateral vertical veins were continued uninterruptedly on its sides.

The same vertical opening sometimes presents different arrangements in different parts of its course; in one part, only a single vertical vein, occasionally enlarging into bunches or geodes; and in another part, arrangements such as have been last described; the opening enlarging and varying in form correspondingly. Thus a wide cave opening will sometimes pass at no great distance into a narrow crevice opening, and the arrangement of the mineral will change from that of lateral vertical veins, meeting by cross flat sheets in the roof or below in the opening, to that of a single vertical sheet or vein. This latter will, in some parts of its course, form a proper sheet; in others, a vein marked by cubes, more or less distinct, in regular vein order; and in others, geodes or bunches, and these last either connected by intervening sheets or veins, or more or less detached and interrupted. In the latter case, however, the connexion may be traced by a mineral seam, more or less distinctly marked.

I have already observed that the same crevice sometimes includes distinct sheets or veins, occasionally uniting in one, or connected by cross sheets or veins. In like manner, distinct crevices, with their veins, sometimes unite or are connected by cross crevices and veins. At such points of junction, there is usually an extraordinary increase of the mineral, and the smaller vein is then regarded as a feeder of the larger. The East and West veins are usually the leading veins, and the North and South and quartering veins are then subordinate and regarded as feeders. But usually where cross veins meet a leading vein at such an accumulation or bunch of mineral, they extend only a limited distance from it, and are rather lines proceeding from it as a centre than feeders contributing to form it. When a quartering vein meets a leading vein, on entering the crevice of the latter it often runs parallel to it for some distance, the two connected by a net-work of cross veins, and at last uniting in one common vein. In some instances, two parallel leading veins are connected by such quartering veins, and in others, one leading vein will leave its regular course, and pursue a quartering direction till it unites with a leading vein adjoining. Cross veins are differently affected on meeting a leading vein. Sometimes they pursue the same course, without interruption, on the opposite side, but more usually they are interrupted (cut off,) or else shifted to a greater or less distance. In the latter case, I have sometimes observed particles of mineral disseminated in the rock opposite the vein at its junction with the leading vein, apparently indicating that the shift was not caused by any shift in the rock, of which there were besides no indications. Not unfrequently a leading vein, on meeting a cross vein, will be interrupted or cut off, with its crevice, and apparently shifted by the cross vein to another parallel vein. In one instance, I observed an East and West vein, from which a quartering vein had proceeded at some distance, interrupted in this manner by a North and South, and apparently shifted by it to the quartering vein, when the latter became the leading East and West vein. In other instances an East and West vein will terminate less abruptly, and be shifted to another east and west line, commencing there in the same manner it had terminated; the two overlapping each other to some extent, and sometimes connected by a cross vein or seam near their termination. Usually the cross vein, in such cases, is small, and serves only as a leader from one East and West vein to the other, or the connexion is formed only by a seam of ochre or clay. These arrangements have an important relation to the grouping of veins, and will be farther noticed under that head.

Another mode of lateral shifting is sometimes observed in East and West vertical veins, where the mineral is arranged in a series of more or less detached deposits or bunches. These last range in a direction oblique to the general course of the vein, and usually thin out at each extremity. Each succeeding bunch overlaps the preceding in such a manner that the general course of the vein is continued.

The mineral in the vertical openings is sometimes found only near their cap or roof, and sometimes only in their lower part; sometimes both above and below, but not between; and at other times, more uniformly throughout their whole depth. Not unfrequently it rises and falls alternately in its course, occupying only a moderate extent vertically at any one point, but rising and falling to a much greater. The opening, when it is low and capped over with hard rock, rises and falls, in such cases, with the mineral. This rising and falling is usually by a succession of flats and pitches, or steps, rather than on an uniform line. A similar arrangement occurs in the flat openings in the lower beds. Often the mineral rises above the common level of the openings in the chimneys already described (p. 36-7); in such cases forming bunches at the intersection of the chimney with the horizontal opening, extending upward into the former.

Flat (horizontal) sheets or veins have been already noticed in connexion with the wider openings, both in the soft ground of the opening, and in seams in the cap rock. In some instances, such flat sheets have been observed, of considerable extent, overlying a number of parallel crevices traversed by vertical veins, and in others, of less width, overlying only a single opening or vein. When such a sheet is struck in the upper part of the upper magnesian, it is considered as indicating the near approach of an opening or vein.

More usually, in the upper part of the upper magnesian, the East and West ranges present vertical openings of some width, traversed by veins composed chiefly of square (cubic) or chunk mineral, arranged in the vein order above indicated, while the North and South ranges are only narrow crevices traversed by sheets, marked only rarely by an approach to regular forms. But in some instances, similar sheets traverse East and West crevices, and these are often combined in groups, intervening between or appended to the larger East and West openings. Sometimes a considerable width of rock is found traversed, at short intervals, by such vertical East and West sheets, connected throughout by cross sheets, both vertical and horizontal. These cross sheets, in such cases, are usually thinner and more broken, or even quite interrupted, at the middle point between the East and West vertical sheets, indicating that the latter are the leading veins, to which the former are subordinate. The rock thus traversed is usually softer and more stained, at least towards its seams, and may be considered as forming one common opening.*

In the upper part of the upper magnesian, the crevices and openings are usually of less width and more detached than below, and the leading veins arranged vertically, the flat sheets being only appendages to them. The openings, even when widest, such as the large cave openings, are also more generally occupied with looser materials, from a greater decomposition of the rock and matrix. As we descend to the lower part of the upper bed, the openings become wider, although in most instances the vertical arrangement continues to prevail. In this part of the upper bed, very wide openings are found, occupied by portions of the limestone rock, either decomposed to sand, or in detached harder masses (tumbling rock,) and intersected throughout in different directions by mineral veins, usually accompanied with seams of clay and iron; the East and West vertical veins predominating.

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* An example of this occurs in one of the ranges of Norris & Haskins, at Vinegar Hill.

The mineral in these veins is usually in more or less detached masses (square and chunk mineral,) but sometimes in thinner sheet forms, usually broken. In some instances at least, those remarkable bodies of mineral, called patches, found directly beneath the surface clay, appear to have been such openings exposed by denudation. Those to which I here refer are no longer worked, but are found in the same position in the strata, and in some instances, in the vicinity of such openings, and from the description I have received, corresponded to them in character.*

Another class of wide flat openings, called flat sheet mines, are found in this lower part of the upper bed. Here the horizontal arrangement predominates; the mineral having a sheet form, similar to that of the vertical sheets, and closely wedged in the rock, or more usually in a narrow flat crevice, in which it is bordered by seams of clay or iron, and occasionally interrupted by the same, or by calcareous spar. These flat sheets appear more subject to interruption than the vertical sheets, and then often form a series of lenticular masses, thickest at their centre and thinning off towards their edges. They vary, like the vertical, in thickness, from a fraction of an inch to several inches, and are connected by cross vertical sheets, in different directions, which are small and subordinate; but occasionally the flat sheet gives out as it approaches a vertical sheet, and the latter assumes the place and direction of the former. Two and sometimes three such flat sheets are connected together in this manner, the rock between them being softer and more stained than that immediately above and below, forming properly a flat opening, but not marked by the peculiar characters of the opening rock in the flint bed below.†

In some instances, when from the vicinity of valleys or ravines, or in deep mining, shafts have been sunk through the upper bed into the flint bed, as at Shullsburg, vertical crevices have been traced down through the former into the flat openings in the latter. In such cases, in the lower part of the upper bed the vertical openings spread out laterally, and at the same time that they carry down a vertical vein, in the middle line, from the crevice above, present flat deposits of mineral, similar to those in the flat openings of the flint bed, but less extensive; thus marking a transition from the vertical openings above to the flat openings in the lower beds.

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* The Finney Patch, in the S. W. Platteville Diggings, and Jones' range, N. of Elk Grove, may be referred to as examples,

† Examples: Harris' flat sheet mine, S. W. of Galena, and Jackson's, on Bull Branch (Benton.)

The flat openings in the flint bed are remarkable for their horizontal extent and their arrangement. They vary in width from less than ten to 40—50 feet, and are wider in some localities than in others. Generally they are traversed by vertical crevices, marked by seams and sometimes by openings in the roof, but these are sometimes wanting, and the vertical crevices are then found traversing the hard rock between the flat openings. Thus it is common at Benton, to find narrow vertical crevices between the wide flat openings, and these last are sometimes arranged in pairs with a vertical crevice between; the interval separating the two being much less than that separating them from the flat openings adjoining. The two thus combined, with their intermediate crevice, are considered as forming one range. In one instance (at Shaw's Hollow, S. W. of Benton,) a wide flat opening, without a vertical crevice, adjoined on the north a number of narrower flat openings, each with its vertical crevice; but in this instance, the whole extent, at least of the latter, might be regarded as one common opening or soft ground. The rock in these flat openings usually presents a peculiar mottled appearance, whence it is called calico rock in some localities. The cause of this I have already referred to. This rock appears to have resulted from the decomposition of a hard blue or grey rock, intersected more or less completely by seams of iron pyrites, or rather of rock more or less filled with disseminated pyrites, dividing it into small rounded nodules, more compact than the intervening seams. This structure can not have been derived from the fracture of the rock and the injection of the seams, but has been the result of a process of segregation, by which the more compact limestone was formed at centres, around and between which the more crystalline portion with the pyrites was arranged. The strong tendency of iron pyrites to decompose, under certain circumstances, particularly when minutely disseminated, has caused the disintegration of the limestone in which it was dispersed, and its own conversion into oxyd of iron, giving the stain to that part of the limestone. This hard blue pyritiferous rock is still found unchanged, in some of the flat openings in the flint bed, as in Champion's level (New Diggings,) where it occupies the position of the opening or calico rock, and like that is more or less productive in mineral similarly arranged.

The mineral in the flat openings is generally arranged in horizontal courses adjoining the roof or the floor, but sometimes in intermediate positions. Sometimes it forms a connected sheet of some extent, but more usually occurs in larger or smaller detached masses. These are generally more or less convex on one side and concave on the other, and are so arranged that the convex side is directed downwards. The concave side usually embraces a portion of the limestone harder and less stained, and sometimes the mineral is observed more or less completely surrounding the latter, but much thicker below than above. In this case, the mineral appears to have been formed around the nucleus of limestone in the same manner as the iron pyrites, as above explained. The courses of mineral are very often if not generally accompanied with a layer of flints, usually above the mineral, sometimes below, and occasionally the mineral is interposed between two layers of them. Sometimes the mineral, when detached and isolated, is associated with flint in the same manner. Though the mineral is chiefly arranged in flat courses, yet it is often found detached in every part of the opening, but is then arranged horizontally.

Vertical seams of mineral occasionally pass from one course to another, or traverse the opening as cross sheets, and at the crossing of these or even of a barren seam only, there is usually an increase of mineral in the flat courses, sometimes enlarging them so as to form geodes lined with regular cubes. When vertical East and

West crevices traverse these openings, they usually carry a vein of mineral arranged in vertical order, intersecting the flat courses; but in some instances I have observed such vertical veins on the sides of the openings, inflected under the roof into the horizontal course, with an enlargement of the mineral at the turn, sometimes forming there a geode. In some instances, the vertical crevices, which have been traced from the rock above into or between the flat openings, have been found to carry mineral more or less through their whole extent; but in other instances, the mineral extends in them little or not at all above or below the opening.

The lateral limits of these flat openings are generally marked by a slight turn in the courses of mineral from a horizontal to a vertical position at the sides of the opening, beyond which the rock soon loses its opening character; thus showing the definite extent of these horizontal deposits.

Some peculiarities, worthy of notice, are observed in different localities. In the flat openings at Benton, particularly at Swindler's ridge, a layer of hard rock, 1—2 feet thick, called the false cap, immediately overlies the openings, above which is a layer of flints, usually accompanied with a flat sheet or course of mineral, often of workable value. This layer requires support, and when such support is withdrawn, after the opening is worked out beneath, soon falls and exposes the mineral above it. The rock above, called the true cap, usually remains firm, even in the widest openings. In the flat openings at New Diggings, a layer or bed of hard rock with flints, about three feet thick, overlies the opening rock, and is overlaid by a thin subargillaceous layer, called the grey shale, apparently of a concretionary structure, and interrupted by mineral, arranged in a horizontal sheet form, detached or more connected. The rock above this contains very few flints; the proper flint stratum commencing in the bed immediately below it. A layer closely resembling the grey shale in character occurred at the Dry Grove Diggings, west of Benton, in sinking on a vertical sheet, at the upper surface of the flint bed.

The flat openings of the flint bed, occupied by the calico rock, are found throughout a large portion of the mineral district, where openings have been worked in that bed, and are the most general and characteristic of those in that bed. I have observed them, well marked, at Beetown, Potosi, Brushhill, Platteville, Elkgrove, Benton, New Diggings, Shullsburg, and the Dreadnought mine near Mineral Point. In some of these openings, the rock is much more disintegrated than in others; its ground, in such cases, being reduced to the state of loose sand, with more or less tumbling rock; while in others, although distinctly marked, the rock is so hard as to require blasting. Openings of the former kind are called sand openings, and are common at Benton, while at Shullsburg openings of the latter kind are more frequent.

Occasionally in the localities above mentioned, and more so in the more eastern diggings, the mineral is collected more in bunches, particularly along the line of vertical crevices, and is then more accompanied with clay and iron, and more disposed to assume regular cubic forms, approaching in these respects the arrangement in the vertical openings in the upper bed. But in such instances, the intervening rock is more or less altered and stained, the whole forming a common opening. In some cases, as at Chenaworth's mine, near the Dreadnought (above noticed,) this arrangement in bunches, along the lines of crevices, appears to have arisen from masses of rock, intersected throughout, as in the calico rock, by distinct seams of iron pyrites, accompanied with more or less mineral, which by their decomposition form masses of ochry earth and hematite, including the mineral as in the rock. These masses are sometimes so rich in mineral as to be very productive. Sometimes they will be found entirely decomposed; at other times, only partly so; and even in some instances, entirely unchanged; thus showing satisfactorily the origin of the former from the latter, and their relation to the calico rock. It might indeed be expected that where the pyrites is so concentrated as in these instances, it would be less extensively diffused through the rock, and more segregated in bunches, whereas the calico rock, in which the pyrites is more disseminated, would be found characteristic of larger and more uniform openings. This arrangement in bunches is more peculiar to the flat openings, east of the parallel of Shullsburg and Mineral Point; but these openings form ranges as regular in their course as the more uniform flat openings farther west.

Calcareous spar is generally very rare in the flint openings; but occasionally it is found, either disseminated through the opening rock, or more frequently accompanying the layers of flint and mineral; the regular order from above downwards, being then calcareous spar, flint and mineral. Even in some instances where there are no traces of a mineral opening, calcareous spar is found accompanying the layers of flint in the same order. I have observed, in one instance, in Stephens' mine (Shullsburg,) a mass chiefly composed of calcareous spar (*tiff*,) occupying a large extent of an opening, and arranged like the masses of hard blue pyritiferous rock in some openings, as in Champion's level (New Diggings.) These masses rise sloping inwards from the bottom of the opening to a ridge near the roof, and apparently extend downwards in the manner of a lode, but have not been proved in that direction, and terminate abruptly or taper out at the extremities. The mass of tiff, in Stephens' mine, terminates abruptly towards the west, and apparently tapers out towards the east. At its west end, it is bordered by a thin layer of hard rock, in nearly a vertical position, as if out of place, but more probably formed in its present position by segregation. This layer is traversed by small vertical veins of mineral, and in the calcareous spar adjoining, which is there more massive, the mineral is found accumulated, usually in very regular cubic forms, although closely imbedded in its matrix. In some other parts of the mass, similar accumulations of mineral were found, but in general the mineral is only sparsely disseminated. The entire mass appears to be a portion of the rock arranged conformably to the stratification, the greater part of it composed of the calcareous spar, disposed in segregative order through a base of the granular limestone, through which iron pyrites and more or less of copper pyrites are disseminated; the latter also collected at particular points in small bunches.

The flat openings in the flint bed are usually not more than four to six feet in height, particularly the wider and more uniform openings, and two openings are generally found, one above the other, separated by a layer of hard rock, about two feet thick, forming the cap of the lower. In a few instances, a third opening has been found. These may all be considered as one common deposit, with which the flat sheet above the false cap is connected. These openings, like the vertical openings in the upper bed, sometimes rise and fall in their course, by a succession of flats and pitches; or this rising and falling, as in the latter, is only confined to the mineral, the opening remaining unchanged. The most uniform flat openings are more or less subject to interruption in their course by transverse bars of rock, and in some instances, the detached portions have a form more or less rhomboidal, analogous to the form of the bunches observed in some vertical East and West ranges in the upper bed (p. 44,) and also succeed each other in a corresponding order. This is observable in the flat openings at Swindler's ridge (Benton,) where the longest diameter is from north-west to south-east, corresponding to the general direction of the ranges (E. S. E.)

In the lower bed of the upper magnesian, flat openings are the most general, and even more extensive than those in the flint bed. In some instances, such openings have been worked across more than a hundred feet, without reaching their limits. In one instance (at A. Looney's level, north of New Diggings,) a side drift was carried from the middle crevice near fifty feet before reaching the limit of the opening ground. This limit was very distinctly marked by a vertical line, the adjoining rock losing at once the peculiar characters of that of the opening. I have already observed that the rock in the lower bed is less uniform than that in the flint bed, and the same is true of the openings. The black or brown rock and the green rock, in their different districts, have important connexions with these openings, generally overlying and including them, whence they are usually called the black or green rock openings. In some instances, however, the rock in these openings resembles that of the flat openings in the flint bed, or the calico rock, and is then more or less accompanied with layers or nodules of flint, which seem to be confined to the opening rock, or are at least most abundant in it. But even then this opening rock is distinguished from that of the flint bed by the great abundance of calcareous spar (*tiff*) disseminated through it, as is common in the brown rock, and usually more or less of it has, by its stain, the character of that rock. When the opening rock resembles the calico rock of the flint bed, the adjoining rock is usually very hard and compact, and of a light grey color, resembling the hard nodules found in the opening rock, particularly of the flint bed, and the more compact layers of the upper bed of the blue limestone. This adjoining rock is destitute of the ferruginous stain and the disseminated tiff, characteristic of the openings.

In this lower bed the mineral is usually found more accompanied with the sulphurets of zinc and iron than in the two upper beds. The sulphuret of iron, or the result of its decomposition, is always present more or less in the openings in the upper beds. Usually the sulphuret has been there converted into the oxyd, causing the ferruginous stain and the deposits of ochre and hematite (iron rust) found in those openings. The sulphuret of zinc (black-jack) and the carbonate (dry-bone,) the result of its decomposition, are more rare in the upper openings, but are occasionally found there, more frequently, so far as I have observed, in the vertical openings in the upper bed than in the flint openings. But there is a class of veins (the flat and pitching sheet veins,) which have been traced through all the beds of the upper magnesian into the blue limestone, in which zinc ores are usually found more or less accompanying the mineral. Not only in these, and in those instances where the zinc ores accompany the veins in the upper vertical openings, but also in those where they accompany the mineral in the flat openings of the lower bed and the blue limestone, there is an order of arrangement which I have found invariable. When the ores of lead, zinc and iron are all present, the iron ores are arranged in a sheet or layer next the rock, then the zinc, and then the lead, in succession, towards the interior of the opening. In the Marsden lead, below Galena, (a flat and pitching sheet mine,) where the mineral is usually accompanied with zinc and iron, this order is distinctly observed, and in different geodes, processes, like nipples, are observed projecting into the cavities or geodes between the cubes of the mineral, which are found occupied in the centre by a square process from the sheet of iron pyrites, like an elongated cube, surrounded with a coating from the black-jack, sometimes with points of mineral adhering to the surface. The flat and pitching sheet veins with zinc and iron, usually called flat and pitching dry-bone sheets, have been found to commence in the upper bed of the upper magnesian, and have been traced down through the different beds of that rock and of the blue limestone to the upper sandstone. At the west end of the Heathcock range (Linden,) the same sheet has been followed down from the flint bed to at least ten feet in the upper bed of the blue limestone, and is there found large and productive, and without any sign of interruption. These veins appear indeed to be the most uninterrupted, and in some instances have been worked more than twenty years without exhaustion, and with a very uniform product.*

The ores of zinc are rare in some of these flat and pitching veins, the mineral being then connected immediately with the ores of iron. But where the zinc ores are more abundant, they are sometimes nearly or quite wanting in parts of the vein, and then usually the lead ore is increased in proportion, while in other parts of the vein the zinc ores predominate. Thus in one part, the vein will be found narrow or divided in the rock of the opening, and the mineral more or less disseminated in the zinc ore, so as to require separation by crushing and washing; then, where the vein is wider, the mineral will form a middle sheet, detached from the zinc ore, and where still wider, a geode will be formed and the mineral be arranged in cubes on the interior surface of the zinc ore. Still farther in its course, the zinc ore will disappear, and a thick and solid sheet of mineral be found, separated from the rock only by a seam of iron. Such thick and solid sheets are usually found on the flats, and the geodes at the turn from a flat to a pitch, extending more or less along the latter. These flat and pitching veins sometimes pitch in opposite directions from the same flat, forming what is called a saddle-back. In some instances, such a flat is apparently at the highest part of the vein, forming a longitudinal ridge along its middle, from which it pitches on each side, either in one uniform slope, or by alternate flats and pitches. Such is the arrangement of the sheet in the Heathcock range, where it forms a flat, at its summit, in the flint bed, from which it pitches on each side into the lower strata; on the south, at least into the upper bed of the blue limestone. This flat is much wider towards the west, where the sheet pitches on each side more uniformly, but narrows out towards the east, where the sheet pitches uniformly on the north, but on the south, descends more in alternate flats and pitches, and apparently divides into 4—5 smaller sheets, connected in a common opening. In some instances, such flats are only on the general pitch of the vein; the vein rising, then turning over a flat, and then pitching again in its regular course. I have not yet had an opportunity of tracing such a vein lower than the upper bed of the blue limestone; but I have been informed by J. Bracken, Esq., that such a vein, in the Victoria range (Mineral Point,) was followed down to the base of the blue limestone, and that the accompanying zinc and iron ores were even traced into the upper sandstone. These veins, like the vertical sheets, thus appear to have an extensive range through the strata, and are not confined to one particular bed, like the flat openings in the lower strata, and the more limited vertical openings in the upper bed of the upper magnesian.

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* This is reported of the Heathcock range (Linden) and the Dry-bone mine on Bull Branch (Benton,) both of which are still worked to advantage.

The flat openings in the lower bed may be divided into three classes: Sand, ochre and dry-bone openings. The first class includes those, where the opening rock resembles the calico rock of the flint openings, and is usually accompanied with more or less flint, like the latter. The mineral is here arranged in flat courses, or disseminated horizontally through the rock, as in the flat flint openings. These openings too are traversed by vertical crevices, (either of more uniform width or forming a series of pockets,) usually occupied by loose materials, and adjoining which the rock is more decomposed than in the remoter parts of the opening. The mineral is most abundant in the loose ground of these crevices, and in the adjoining parts of the opening, where the rock is most altered. Generally, in the loose ground of these crevices, a much greater quantity of iron is found, in the form of unaltered pyrites, or recomposed into ochre and hematite, than in the openings or crevices in the upper beds. In some such instances, the iron pyrites appears to have replaced the mineral, and extensive bars occur in the course of the crevice, in which the mineral is wanting, but the iron ores are proportionally more abundant. Such a bar, at the west end of A. Looney's level, in the middle crevice of the opening, replaced the mineral, after it had continued productive for 800—900 feet, and in this the ores of iron were found in every stage from the original pyrites to the ochre and hematite, exhibiting, in their change, fine specimens of green copperas, and small pockets of alum, where clay was more abundant, and also, though more rarely, of native sulphur. This mass is now partly worked out, the former character of the opening being resumed beyond it. The loose materials in these crevices are arranged conformably to the stratification; the layers of flints crossing them regularly in the line of those in the adjoining rock, only sometimes slightly lowered by the settling of the materials. This loose ground differs from the adjoining rock only by a greater proportion of clay, sometimes forming layers, or segregations investing the mineral as a matrix, and by the quantity of iron intersecting it in the manner already described (p. 47–8.) The more altered rock adjoining resembles the corresponding rock in the flint openings, and is more or less disintegrated in the state of loose sand.

The ochre openings are characterized by the great abundance of iron ore (iron pyrites and the results of its decomposition) accompanying them throughout their extent. Clay also abounds in them, in layers and pockets conformable to the stratification, and in seams corresponding to the outline of the opening. This clay is strongly marked by the smooth joints common to the clay of openings, particularly to the seams of clay which traverse and line them, and is called joint clay and soap clay, by the miners. The latter term is more particularly applied to a bluish clay, breaking in small jointed fragments, which usually invests the mineral when imbedded in clay. The mineral, in these openings, is either arranged in uniform horizontal courses, or in a series of flats and pitches, limited to the openings. In the former case, it resembles, in its arrangement, the mineral in the flat flint openings, but is more connected with clay and iron. In the latter case, it is arranged more in sheet form, bordered by a sheet of iron, and replaced by the same, when interrupted. Usually the mineral is largest and most uninterrupted on the flats, or on the turn from a flat to a pitch, and is smaller and more interrupted, and often entirely wanting, in the pitches, resembling, in this respect, that in the flat and pitching veins already noticed. A remarkable instance of this occurs in a very productive mine, worked by Earnest and Spenceley, on the Shullsburg branch, north of New Diggings.*

The zinc or dry-bone openings are, on the whole, the most frequent in the lower bed, though in some instances more rare, particularly in the eastern districts. In these the mineral is arranged in sheets, with the ores of zinc and iron, in nearly or quite the same manner as in the flat and pitching dry-bone sheets already noted. The same order is observed in the arrangement of the different ores in relation to the rock, and the same arrangement of the mineral in the sheet, sometimes disseminated in the zinc ore, and sometimes forming a separate sheet, between the lateral sheets of zinc, but more usually, in these openings, the former. The sheets, in these openings, are sometimes regularly horizontal, but more usually uneven, presenting a series flats and pitches or undulations, sometimes along slopes of large extent and in different directions, but still limited by the extent of the opening, both in a vertical and horizontal direction. In some instances, although these sheets have been worked to the width of a hundred feet, their lateral limits have not been reached, their sides thinning out so as not to repay the expense of working. In these dry-bone openings different sheets are found, as well as different courses in the flat flint openings; usually one near the roof, and another near the floor, and sometimes others intermediate, the whole more or less connected by cross veins or seams. The opening rock is usually very much decomposed and stained, and more or less accompanied with seams and pockets of clay, as in the ochre openings. Both the ochre and dry-bone openings are traversed by vertical crevices, in which the mineral is arranged in vertical vein order, and is more regular in its form, as in the upper vertical openings. The mineral in these crevices, when they traverse the dry-bone openings, is not accompanied with zinc ores, but resembles that in the crevices in the ochre openings. Usually the mineral in the flat openings is larger and more abundant adjoining the crevices, and in the dry-bone openings, the sheet is enlarged, and the mineral more distinct from the zinc ore, sometimes even forming geodes. The dry-bone and ochre openings generally alternate, either one by one, or in successive groups. In some instances, the same range will in one part of its course be an ochre opening, and in another, a dry-bone opening. I have known the same range commence on the west with a mass of iron ore, then become a productive ochre opening, and terminate towards the east in a dry-bone opening.

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*I have observed in some of the ochre openings, layers or more detached masses of a white limestone, usually much disintegrated in the state of sand. A similar rock also occurs in the Upper Pipe-clay openings in the blue limestone.

The great quantity of calcareous spar (*tiff*) disseminated in the opening rock, and even in the rock generally, in the lower bed, particularly in the brown rock, has been already noticed. In some of the openings in this bed, large masses of calcareous spar are found, usually in horizontal courses, with more or less of a geodic arrangement, the crystals aggregated so as to present the appearance of rounded bosses of a peculiar form. These masses usually occur along the lines of vertical crevices, and are sometimes found, in such cases, in small caves; the opening being only partly filled with the spar and the loose materials accompanying it. The latter are usually derived from the decomposition of subargillaceous layers, more or less accompanied with iron pyrites, and sometimes with the black oxyd of manganese (black ochre.)

Beds or bars of pyritiferous rock also occur in the openings of the lower bed, more remarkable even than those in the openings of the flint bed. They either underlie the opening rock near the base of the upper magnesian, or rise in the openings, as has been noticed of the bars in the flint openings, and consist of regular beds of the limestone, nearly filled with seams and bunches of iron pyrites, accompanied with more or less calcareous spar;* the whole forming by its decomposition a bed of ochry earth and hematite, and presenting during the process of decomposition the same appearances as have been noticed in the bar at the west end of A. Looney's level. In one instance (at Blinkiron's mine, north of New Diggings,) I observed such a bed underlying the opening, and overlaid by a bed of bluish grey limestone largely filled with bunches and geodes of calcareous spar, in small and often very perfect tabular crystals of great clearness and beauty.

The openings in the lower bed, particularly in the eastern districts, sometimes present a succession of pockets or bunches traversing the general opening rock, corresponding to a similar arrangement in the flint openings. In some instances, I have observed such an arrangement in smaller upper openings immediately overlying the large and uniform flat openings in this bed. The brown or black rock generally accompanies the openings in the lower bed in the south-western districts, and the green rock in the north-eastern districts; whence at Mineral Point and in its vicinity, the openings in this bed are known as the green rock openings, while in the south-western districts they are called the black rock openings.

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* The calcareous spar generally forms segregations invested by the iron pyrites, and on the decomposition of the latter is sometimes found changed to the sulphate of lime (selenite.)

In some instances, detached vertical crevice openings are found in the lower bed, traversed by a vertical vein, from which flat courses of small extent (2—3 feet) enter pockets in the sides of the crevice, showing a tendency to the formation of a wide flat opening, traversed by a vertical crevice and vein. These resemble the openings of an intermediate character between the vertical and flat openings, already noticed in the lower part of the upper bed.

Small quantities of copper pyrites have been observed, in different instances, in the openings in the lower bed, particularly in the vicinity of Fever river, accompanying iron pyrites or calcareous spar. Frequent traces of it occur in the masses of iron pyrites in the openings of the lower bed at W. Gillet's diggings (Buncomb,) and in connexion with the large masses of calcareous spar in openings in the same bed, above noticed, in different ranges between Fever river and the Shullsburg branch, east of Benton. In the latter case, the copper ore occurs near the junction of the spar with the rock, where the two are more or less blended, much in the same manner as it occurs in the large mass of tiff in Stephens' mine (Shullsburg.) The copper pyrites is always accompanied, in these instances, with more or less of the green and more rarely with the blue carbonate. The copper ranges at Mineral Point have also been worked chiefly in the lower bed.

It has been a common opinion that the blue limestone cuts off the mineral, and this has been understood of the blue limestone of Owen, or the formation immediately underlying the upper magnesian. This opinion has properly no reference to that rock, but to beds of hard blue rock found in different positions in the upper magnesian, which in many instances have been known to interrupt the mineral in its descent, both in sheets and in wider openings. This rock is usually more or less intersected with iron pyrites, and has been found at the bottom of openings in all the beds of the upper magnesian, and sometimes rising into the openings and forming obstructions in their course, or intervening as a bar between contiguous openings. It may be considered as properly an opening rock, and when cutting off the mineral, as playing the same part as the masses of loose ferruginous materials which interrupt the mineral in the course of openings or veins, particularly in the lower bed of the upper magnesian. I have described the different openings, in their descent, as forming series at different levels; two in the upper bed (the upper and lower,) the flat openings in the flint bed, and those in the lower bed (the brown and green rock openings.) These beds or bars of pyritiferous rock appear to underlie occasionally all of these openings. In sinking on a vertical sheet traversing different beds, it is found liable to interruption on meeting such bars, but not always so; instances having occurred in which the sheet has traversed them, but usually more or less diminished in its passage. When such a bar underlies an opening, or interrupts a vertical sheet, usually for a certain distance beneath more or less of the mineral is disseminated through it in particles or seams. I was informed by Mr. Haskins of Dodgeville, that in one instance a vertical sheet, on which he was employed, was cut off clean by a floor of blue limestone, only small particles and seams of mineral being found in it for a short distance below the sheet. On examining the rock, I found it was only a modified portion of the common rock of the locality (the flint bed of the upper magnesian,) forming such a bar as I have described.*

The Blue Limestone of Owen is a good mineral-bearing rock, and like the upper magnesian, not only has its openings in each of its three beds, but is traversed by vertical and pitching sheets or veins, which in some instances are said to have been traced through it to the upper sandstone. I have myself traced pitching sheets from the upper magnesian into the upper bed, and vertical sheets to the lower bed or buff limestone. The regular openings in the blue limestone are wide and flat, like those in the two lower beds of the upper magnesian.

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* These bars have been met in sinking below the different openings, and in following down vertical sheets, and from their great hardness have discouraged from farther pursuing the mineral downward. From observation it has appeared to me evident that they are parts of a mineral range, in which iron pyrites replaces the mineral, and are of limited extent, and need not obstruct the progress of mining. Before attempting to work through them, it would be well to determine their extent by boring, which might be effected with comparatively little expense.

The openings in the upper shell bed are called the pipe clay or brown rock openings. The former name is taken from layers of clay which traverse the openings, derived from the decomposition of the layers of shale which are interposed in the upper bed; the latter, from a bed of brown rock, already noticed, immediately overlying the upper bed, and forming a more or less immediate cap to the openings. These openings are merely a certain extent of the rock, which has suffered more or less decomposition, and through which the mineral is disseminated in flat courses, usually imbedded in the layers of clay above noticed. The rock in these openings is, on the whole, less stained than in the openings in the upper magnesian, and the mineral is less accompanied with iron. It is also more regular in its form, sometimes in very perfect cubes, but more often tabular, varying in size from very small, called dice mineral, to very large; the latter usually adjoining a vertical crevice. The mineral, whether large or small, is imbedded in the clay or shale, in the same manner as iron pyrites in pyritiferous shales, and is either quite isolated, or a series of cubes or tables is arranged in horizontal vein order, sometimes forming sheets of considerable extent. These openings are usually wide, sometimes equalling in width those in the lower bed of the upper magnesian, but in such cases the mineral is more confined to the vicinity of vertical crevices, although the intermediate rock is much decomposed, and contains more or less mineral disseminated. In some instances, I have found this change in the rock, with the accompanying mineral, extending only a few feet (6—8) on each side of a vertical crevice; the adjoining rock having the usual characters of the unaltered blue limestone and abounding in fossils, while in the altered rock of the opening the fossils are so decomposed as to be hardly distinguishable. In some instances, as in the Irish Diggings near Mineral Point, the openings in this bed are very ferruginous, and the mineral is then sometimes accompanied with zinc ores, forming flat sheets similar to those in the lower bed of the upper magnesian. In some instances too, masses or bars of hard compact rock are found in these openings, intersected by very thin seams of mineral, and with small points of it disseminated, analogous to the hard blue bars in the upper magnesian. The openings in the upper bed have been worked at Mineral Point and Platteville, north of New Diggings, on the Yellow Stone, and in other localities in the eastern districts. In some instances, these openings have been very productive, particularly at Mineral Point, in the McKnight range, and in Bracken and Murrish's range on the Mineral Point branch, south of the village. Near Platteville, at the Back-bone (a narrow ridge between the Little Platte and the Rountree branch,) the occurrence of dice mineral (in the upper bed of the blue limestone) has been long known, and openings in that bed are now worked there to advantage.

The openings in the middle bed of the blue limestone are usually called the glass rock openings. They are situated either in the lower more compact parts of that bed, the upper fine-grained portion overlying them as a cap, and more or less stained of a brown color, as it approaches the opening, or beneath the middle part or proper glass rock, in the lowest division of the bed, adjoining the buff limestone. In the glass rock openings, more variety has been observed than in the pipe-clay openings above mentioned. In some instances, they are dry-bone openings; the mineral being accompanied with zinc ores, forming sheets, arranged as in the corresponding instances in the upper magnesian. These sheets are generally quite horizontal, though irregularities in their course are sometimes observed, particularly where crossed by vertical crevices. The same alternations of enlargement and contraction are observed in the sheets, as already noticed; the mineral, in the latter case, being disseminated through the zinc ore mostly in the middle line of the sheet, and in the former, usually forming a distinct middle sheet, and sometimes a geode. These geodes are sometimes occupied in the centre by calcareous spar or sulphate of barytes, or by the two in distinct segregations. At the crossing of vertical crevices, there is usually an increase of the mineral, in larger and more regular forms. In some of these dry-bone openings, the sulphuret of zinc (the original ore) has been very little changed; in others, it has been chiefly converted into the carbonate or silicate (dry-bone.) The former is the case at Haswell's mine, west of Mineral Point village, and the latter at the Falling Spring mine, south of the village. The cause of such a difference is not very obvious. The finest specimens of the carbonate of zinc yet seen by me, were found in the dry-bone sheets in the openings in the blue limestone near Mineral Point, particularly at the Irish Diggings. In other instances, the glass rock openings are without zinc ores; the mineral being found under circumstances similar to those under which it is found in the pipe-clay openings. The greater part of the openings in the South Forked-Deer Diggings, on Wood's branch, are glass rock openings of this character. Only one dry-bone range (Woffal's) occurs in those diggings, parallel in its direction to the other ranges. In these openings, there are usually two courses of mineral; a lower, in a layer of grey shale, similar in its character to the grey shale in the flint openings at New Diggings, in which the mineral is of the same cubic or tabular form and imbedded in the same manner as in the layers of clay in the pipe-clay openings; and an upper, in which the mineral forms a flat sheet, more or less interrupted or broken by interposed clay and calcareous spar. These openings are of great width, but low, and the rock between the courses of mineral is generally hard, which renders it difficult to work them by drifting.

In a few instances, flat openings of no great width have been found in the middle bed, chiefly occupied by masses of calcareous spar, arranged horizontally between layers of clay with more or less iron and sometimes with large quantities of black oxyd of manganese (black ochre.) These closely resemble in structure similar masses of calcareous spar, already described as occurring in the lower bed of the upper magnesian. From the settling of the loose materials accompanying the spar, there is usually a small vacuity below the cap, forming a cave. A remarkable instance of this kind occurs in the middle bed of the blue limestone, just north of Quinby's quarry, already referred to. Such openings with calcareous spar have not yet been found productive in mineral. An opening of a similar kind, but of greater width, has recently been found at Meeker's Grove (Buzzard's Roost) in the glass rock, chiefly occupied by similar horizontal masses or beds of sulphate of barytes, accompanied laterally with small quantities of calcareous spar. There are two such beds of sulphate of barytes, one above, another below, separated by a bed of clay with small points of calcareous spar, barytes and iron disseminated. In these beds of sulphate of barytes, mineral is found firmly imbedded, and in such quantity as to be worked to good advantage; usually of a regular form and brilliant surface; a series of larger more detached pieces arranged along the middle of each bed, and a more connected series or sheet of smaller pieces along the sides, above and below. This is the only instance of the kind I have yet observed; but mineral has been found imbedded in sulphate of barytes, in openings in the lower bed of the upper magnesian in that vicinity. The glass rock openings have been worked most extensively at Mineral Point, where some of them have been very productive.

Openings have been found in the lower part of the lower bed or buff limestone, generally wide and flat, and strongly resembling good mineral openings in other beds, but have not yet been fairly proved. They are sometimes traversed by layers of clay, derived from the subargillaceous layers of the rock, and in such cases resemble much the upper pipe-clay openings, from which circumstance they have been called the lower pipe-clay openings. In other instances, they are found to contain large quantities of calcareous spar, in masses similar to those in some of the glass rock openings, with more or less mineral and some zinc ore connected. Large openings of this kind, in the lower bed, have been reached by sinking below the glass rock opening, at the south Forked-Deer Diggings, and at Haswell's mine near Mineral Point. In a few instances, near the latter place, considerable quantities of mineral are reported to have been taken from openings in the lower bed near its outcrops.

A remarkable opening in the blue limestone occurs at the Aspen Grove mine (Shook's Prairie, Green Co.,) apparently traversing different beds of the rock, and in its character, unlike any other which I have examined. It forms a very wide vertical East and West crevice, with regular walls, occupied by an opening rock, more or less traversed by seams of mineral and iron pyrites, distinct or combined, intersecting the rock in a manner similar to the arrangement noticed in some of the flint openings (p. 50.) The mineral in these seams is composed of small cubes, more or less regular, grouped in sheets or small bunches, and is accompanied by more or less of crystallized carbonate of lead, often very distinct and regular. This is sometimes in large quantity, but has appeared to me only subordinate to the sulphuret. The opening is divided towards the west by a large key-rock, running out in a point towards the east, adjoining which the mineral is said to have been most abundant.

The Upper Sandstone, so far as I have been able to ascertain, has not yet been found to contain mineral either in crevices or openings; but a sheet of zinc ore and iron pyrites at Mineral Point, already referred to (p. 55,) is said to have been traced 2—3 feet into that rock, in the line of a crevice bearing mineral to the base of the blue limestone. Copper ore is also said to have been found in the sandstone at the depth of several feet, in the same vicinity. It is thus not improbable that if the mineral is interrupted in the sandstone, ores of zinc and copper may be found there in its place.*

If the mineral is interrupted in the upper sandstone, it reappears in the Lower Magnesian. Numerous instances are stated of the occurrence of mineral in the lower magnesian in Owen's reports (1847, 1852,) and several other localities have been mentioned to me by different individuals, near the Mississippi, and in the country between it and the Kickapoo, north of the Wisconsin. I shall however confine myself here to my own observations. I have not yet had time to explore the country occupied by the lower magnesian to any extent, and have visited no other diggings in that rock, but those in the vicinity of Blue river, known as Oleking's Diggings. These however furnish satisfactory evidence that the mineral occurs in that rock, in as proper openings, in as large masses, and arranged as regularly as in the upper magnesian. These diggings are in the sides of a ravine, 60—70 feet deep, leading to the Blue river, about three miles west of Franklin village. The lower magnesian occupies the sides of the ravine nearly to the summit, where it is overlaid by a low bluff of the upper sandstone. About three fourths of the descent below the sandstone is occupied by a steep slope, formed by the softer upper bed of the lower magnesian, below which is another low bluff formed by the harder middle portion of the same rock. Three successive openings, one above the other, appear to occur here in the lower magnesian; one 8—10 feet below the sandstone, another just above the harder middle bed, and a third below the bottom of the ravine, in the latter bed, and at the depth of about 70 feet in the lower magnesian. The openings appeared partly narrow and vertical, partly wide and flat, with appearances of decomposition and stain in the rock, deposits of clay and ochre, and arrangements of the mineral, similar to those in the upper magnesian. Flint, such as is peculiar to the lower magnesian, is found in the openings, and is connected with the mineral in the same manner as has been noticed in the flint openings in the upper magnesian. The mineral in these openings generally appeared in more or less detached masses (chunk mineral,) often very large, weighing more than 100 lbs; a few even more than 500 lbs.* It was what is called pure mineral, free from iron and zinc ores, and strongly resembled that found in the upper vertical openings in the upper magnesian. After examining this locality, I could not doubt that the lower magnesian is a good mineral-bearing rock.

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*The Ulster lead mine (N. Y.) is in a bed of sandstone, interposed between two beds of limestone. This fact offers some encouragement to expect that mineral may yet be found in the upper sandstone.

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*One mass was reported to have been found weighing 3000 lbs.

I have thus been able to trace the mineral in a series of crevices and openings from the summit of the upper magnesian to the depth of 60—70 feet in the lower magnesian, and have found all the different beds of limestone good mineral-bearing rocks, each with one or more openings, besides vertical or pitching sheets or veins. The small depth to which mining has been extended does not allow one to trace the mineral through the whole of the extent downward in any one instance, but wherever circumstances permit of examination, the order of succession in the openings is found to be regular, and in multiplied instances vertical crevices and veins have been found passing down from one opening to another. It is then probable that the series is generally continued through the whole downward extent indicated, subject only to such interruptions as are more or less common in all veins. The arrangement appears most analogous to that of the lead mines in the North of England, where the veins traverse different beds of limestone, separated by beds of other rock (sandstone or grit, shale, and toadstone or amygdaloid,) but the mineral is chiefly confined to the limestone, the other beds being generally considered barren, and where there is a similar combination of vertical crevices and veins with more or less extensive flats, corresponding to the flat sheets and openings in the mineral district.

In resuming the statements in relation to the openings in the different strata, it will be seen that at least seven well ascertained openings, not reckoning their subdivisions, have been found in the upper magnesian and blue limestone, namely, two in the upper bed, and one in each of the two lower beds of the former, and one in each of the beds of the latter. The lower magnesian apparently presents three in the instance above specified: two in its upper bed (an upper and a lower,) corresponding to the two in the upper bed of the upper magnesian, and one in the lower bed at that locality, which is apparently the middle bed of the whole. Admitting a third lower bed with its opening, the whole number of openings in the lower magnesian would be four, and in the whole series of mineral-bearing limestones (upper magnesian, blue limestone and lower magnesian,) eleven.

## SURFACE ARRANGEMENT.*

In exploring the different diggings, it will soon be evident that there is a great degree of order in the surface arrangement. The East and West as well as the North and South ranges will be found combined in groups, the different ranges in which are almost invariably parallel. The East and West ranges are obviously the leading ranges, to which the North and South and quartering ranges are appended, but the two latter, particularly when arranged in groups, play an important part in the arrangement, and either interrupt the East and West ranges, or shift them laterally to a greater or less distance. But groups of North and South ranges are sometimes interrupted and even shifted by a single East and West range. The bearing of the leading ranges, known as the East and West ranges, it has already been stated, is rarely, if ever, due east and west, even deviating from that course as much as 45° in some instances; but this bearing is uniform in each group, and often in an extensive series of groups. In a single group of East and West ranges, it will be generally found that the ranges have a common limit towards the east and west, but this limit is rarely at right angles to the direction of the ranges; each range successively receding so as to throw the limit into a direction more or less oblique to that of the ranges. The whole group of ranges will thus take a rhombic form, and if we begin at the most western point of the group, will bear either north-easterly or south-easterly, according as the ranges recede from that point on the north or the south. This is called, by observing miners, the direction of the body or weight of the mineral. A remarkable instance of this occurs in the three large ranges, adjoining the village of Platteville, on the Galena road, (Flynn's, Bevins' and the Rountree range.) The north range (Flynn's) extends farthest west, and terminates towards the east nearly opposite the middle of the next range (Bevins',) which again terminates towards the east nearly opposite the middle of the south (the Rountree) range; the body of mineral thus bearing south-easterly. In this instance, the successive ranges recede much more strongly than is usually the case in such groups. In other instances, such strong recessions take place by groups rather than by single ranges; the particular ranges in each group receding but slightly, while the groups recede in the manner above indicated, or even more strongly. An instance of this kind, where the groups succeed each other so as to overlap the adjoining but about half the length of the ranges, occurs in the body of mineral extending from Vinegar Hill (Ill.) to South Buncomb (Wisc.) near the State line. In this instance, the groups of East and West ranges are limited on one side by groups of North and South sheets, which shift apparently by pairs from the east to the west side of those groups. The bearing is to the north-east, but that of the whole body more oblique than that of any single group.

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* My views in regard to the surface arrangement were first formed soon after I commenced my examinations for the American Mining Company in May, 1853, and were stated in reports communicated to the Company in July and August of that year.

The bearing of the body of mineral may be either north-easterly or south-easterly according as the ranges or groups recede to the east on the north or south side of the most western point. In the instance at Platteville, the bearing is south-easterly; in that at Vinegar Hill, north-easterly. In some instances, there is a combination of both, the ranges or groups receding eastward from a given point, both on the north and south sides of it. This is apparently the case in the body of mineral at Vinegar Hill, which, from a point not far south of that locality, recedes eastward both on the north and the south; the whole body making a bend or curve at that point from north-west to north-east in proceeding from the south.

The groups, in some instances, are not marked by a recession in the direction of the ranges, but are shifted (heaved) transversely, at or near their extremity, the entire width of the group, or only partly so. A remarkable instance of this occurs in a body of mineral traversing the South Hazel Green Diggings, where the bearing in each group is N. N. Easterly, but the successive groups shift to the north to a greater or less extent, and are connected at each shift by quartering ranges bearing north-easterly. In this instance, the bearing of the entire body is very oblique to that of each group, and the groups appear shifted successively to the north by the passage of the quartering ranges. But though in this instance the successive groups are shifted to the side on which the ranges recede eastward, namely, to the north, yet they may be shifted in like manner to the opposite side or the south. This occurs at the Hoss Diggings, at the northern extremity of the Hazel Green Diggings, where the body of mineral appears to fall back and curve around from the north-east towards the east and south. In some instances, the groups shift alternately to the north and the south, preserving in the whole the same general direction, and in these instances also, North and South or quartering ranges mark the points of shifting. This may be observed in an extensive body of mineral bearing E. S. Easterly (the direction of the individual ranges,) through Swindler's ridge (Benton.) This may be traced more or less distinctly along a line of 2—3 miles, showing a succession of groups shifted alternately to the north and south, and in some instances marked distinctly by cross ranges at the points of shifting. Thus the eastern group (D. Murphy's) is limited on the west by two cross sheets bearing north by west, and is succeeded, after an interval traversed only by a quartering range bearing north-westerly, by another group (Ellis') shifted to the north, and this by another (J. Edwards') shifted to the south by a cross range bearing south by west. The same succession may be traced still farther west, but less distinctly. In other instances, a series of successive groups or ranges will be shifted to the north for a certain distance, and then to the south, so as to give to the whole a curved outline, like a bow. An instance of this occurs at Shullsburg, in the ranges on the hill south of the village, more particularly in the south range, where the shift is to the north on the west, and to the south on the east, in proceeding eastward. Other instances of curvilinear arrangement appear to arise from successive changes in the direction of the ranges, marked, in some instances at least, by the passage of ravines. Ranges or groups with such curved outlines are called horse-shoes by the miners. The Heathcock range at Linden, and the body of mineral at Dodgeville, on which Washburn & Woodman's engine is placed, have such an arrangement.

I have thus far traced the arrangement of ranges into groups, and of groups into larger bodies of mineral. But even the latter appear connected in more extensive series, traversing a greater or less extent of the mineral district. In such cases, the different orders of succession, above noticed, may be combined; in one part of the series, the groups merely receding to the east, like the ranges, and in another, shifting to the north or south across the ranges; the direction, in the former instance, approaching north and south; in the latter, east and west. The different series also appear conformable to a certain extent in their outline; thus showing a tendency to a general systematic arrangement throughout the whole. This more general arrangement will be best pointed out in connexion with the detail of the local arrangement, and by the aid of the map representing that arrangement.

The relation of the North and South and quartering ranges to the East and West ranges is a subject of much interest and importance. It has already been observed that the East and West ranges are apparently the leading ranges, those which predominate and give the prevailing direction to the mineral. When the North and South or quartering ranges are small and insulated, they are often cut off or shifted by the East and West ranges. They are then considered as feeders of the East and Wests, but are rather only offshoots or branches of the latter. North and Souths and quartering ranges, when larger or grouped, frequently either entirely interrupt or cut off the East and Wests, or cause them to shift to the right or left a greater or less distance. Groups of cross ranges are frequently placed at the termination of groups of East and West ranges, in one or both directions. When the direction of the body of mineral approaches north and south, and the successive groups only recede, or slip by each other, I have sometimes observed these groups of cross ranges only at one extremity of the East and Wests, and alternately, singly or in pairs, on the east and the west. In such cases, they seem to mark the limits of the East and Wests, as well on the side where they are placed, as on the opposite; the ranges being limited in the last direction by the line drawn between the successive groups on that side. This arrangement is observed in the body of mineral extending from Vinegar Hill to Buncomb. In this instance, it is worthy of note that large quartering ranges extend from one group towards another, apparently governed in their direction by the arrangement of the North and South groups; bearing E. N. Easterly, where the North and South groups succeed each other from west to east, and W. N. Westerly, where they succeed each other from east to west.

When the groups of East and Wests are shifted to the north or south, at or near their extremity, the groups of cross ranges serve to connect the contiguous East and West groups at the point of shifting. A series of these may be traced, more or less distinctly, along the whole course of the body of mineral traversing the South Hazel Green Diggings.

In some instances, extensive series of North and South groups occur, traversing a body of mineral in the direction of its bearing, and in these cases, the successive groups are shifted by the passage of one or more East and West ranges. The entire series may be considered as one body of North and South mineral, successively interrupted and shifted by the East and Wests. Two lines of such groups of North and Souths occur in the east part of the North Hazel Green (Jefferson) Diggings, where the North and Souths are shifted to the east towards the south, and to the west towards the north, by the passage of the East and Wests. In one instance, I observed there a North and South sheet apparently rising as it approached the opening in the East and West range, as if to pass above it. In other instances, a group of North and Souths will be interposed between two corresponding groups of East and Wests, generally towards one extremity of the latter; the North and Souths stopping short of the East and Wests, and even of short North and Souths leading towards them from the East and Wests, and the space between the latter, not included in the group of North and Souths, presenting but slight indications of mineral. The group of North and Souths, at South Hazel Green, known as the Phelps lot, is such an instance.

Generally, when ranges having different directions meet each other, one will predominate, and the other be cut off entirely, or if continued, be diminished and soon run out. At the same time, there will be usually an increase of mineral at the point of junction. But in some instances, the two apparently interrupt each other, leaving a space, at their passage, in which little or no mineral is deposited. In such cases, the different ranges appear slightly to affect each other and soon resume their former course. Such instances occurred at the crossing of East and Wests and North and Souths, in the West Diggings at Shullsburg.

The most extended bodies of mineral are usually formed by the groups of East and West ranges, whether arranged in a series bearing north-easterly or south-easterly, or more directly east and west; but in some instances, North and Souths form very extended series. Thus a line of North and Souths, may be traced at intervals from the large North and Souths at the East Blackleg Diggings, which cross the eastern extremity of a large group of East and Wests (the West Blackleg,) to the western extremity of the Shullsburg Diggings, at S. Townsend's, where the mineral again takes an easterly direction. The series is apparently continued in another body of North and Souths, extending from the East and Wests at Shullsburg, 3—4 miles N. N. Easterly, through the Irish Diggings, to the Stump Grove Diggings, where the East and West direction is again resumed.

The East and Wests generally form wider openings in which the mineral is in larger and more detached masses, and in more regular forms, while the North and Souths usually present only narrow crevices, traversed by more even and uniform sheets; but East and Wests not unfrequently take the character of the North and Souths and carry sheets, while North and Souths, but much more rarely, present wide crevices (carrying large and square mineral, like that of the East and West openings,) and even flat openings in the lower strata.* Wide North and South crevice openings, with well marked East and West mineral, have been observed by me, at B. Coe's, on the west side of Fever river (north of Benton,) in the lower bed of the upper magnesian, and at the Irish Diggings, north of Shullsburg, in the upper bed of the same rock, and a North and South flat opening, crossing one of the regular East and West flat openings, at the Brushhill Diggings, in the flint bed. East and West sheets are very rare in some districts, but very frequent in others. Thus, at Dubuque and Fairplay, the East and Wests are generally crevice openings or wider vertical openings, while at Hazel Green, East and West sheets are very frequent, grouped with wide openings, as if appendages of the latter. At Vinegar Hill, a large group of East and West sheets (8—10 in number) is interposed between two of the wide openings. These instances all occur in the upper bed of the upper magnesian. It is a question with the miners, whether these groups of East and West sheets may not lead to large openings beneath. This has been shown to be true at Shullsburg, where mining has been continued from the openings in the upper bed of the upper magnesian into the flint bed, and where different crevices above, bearing mineral, have been found to enter a common flat opening below. Generally, in the wide flat openings in the lower strata, several crevices will be found to traverse the roof, often carrying sheets of mineral.

In the different groups of ranges, whether East and Wests or North and Souths, there will usually be found some one range larger than the rest, called the champion or master range. But in some groups, particularly where the openings are generally large, this distinction is less obvious.

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*In one instance (at Shaw's Hollow,) I observed a North and South sheet terminating at a certain depth (in the flint bed,) in a small cave opening, filled, except near the roof, with loose materials containing much of the black oxyd of manganese (black ochre.)

I have already observed that the term East and West is applied to the leading ranges, although they may deviate even 45° from a due east and west course. On comparing the different diggings, it will be found that a certain order prevails in the bearing of the leading East and West ranges; the different ranges in each usually having a common bearing, and a number of different diggings being found combined into a more extended series by the common bearing of their ranges. Thus the general bearing of the leading East and West ranges is, by the compass, E. 8° N. in the Hazel Green, Fairplay and Lower Menominee Diggings, and in those in the adjacent parts of Illinois and Iowa (at Vinegar Hill, north of Galena, and at Dubuque;) E. 5° N. in the Brushhill, Whig and Platteville Diggings; E. 20° S. in the Potosi, Upper Menominee, Patch and Benton Diggings; also in the Shullsburg and Mineral Point Diggings, and in a large extent of the eastern diggings, chiefly in the northern part of Green county; E. 10° S. in the Cassville and Beetown Diggings; also in the S. E. Platteville and Elk Grove Diggings; E. 5° S. at North Buncomb, Shaw's Hollow and New Diggings; and S. E. in the range of diggings near Fever river, extending from Buzzard's Roost to the Shullsburg branch at Quinby's mill. The bearing of the ranges has thus an important connexion with the systematic arrangement. It should be viewed in this connected manner to give it interest both in a scientific and practical point of view.

On looking at the map, in which I have attempted to give the local arrangement of the diggings, so far as I have examined them, a systematic order presents itself, pervading the whole district, which indicates that the mineral deposits are not casual, but regularly arranged. This may be regarded as an important confirmation of the facts already stated in relation to the arrangement of the mineral in veins. My object, in this map, is not to give all the particular ranges, but only the mode of arrangement, and the relative extent of the diggings. It includes only that part of the mineral district in Wisconsin, already examined, with some of the connected diggings in the adjoining part of Illinois. Had I been able to make a reconnoissance of the whole of the mineral district, the arrangement would have been more complete, and some of the series better filled than they now are; but such as it is, it will serve to illustrate the view I have taken of the subject, and the mode in which I should proceed to investigate it.

The first point to which I would direct attention is the occurrence of several extensive connected series of ranges between which little or no mineral has yet been discovered. These series exhibit a general conformity in their arrangement. Beginning at the south-west, they first bear northerly, then easterly, and then south easterly; thus forming an extensive curve. I have already observed that one of these series (that at Vinegar Hill, Ill.) first bears north-westerly (N. N. W.) and then north-easterly. This course may also be traced in the series next west (that at Hazel Green,) and the observations which I have thus far made in other series would seem to indicate this as the general arrangement.

The different series, which I have been able to trace, are the following, beginning at the north-west: 1. That commencing at the Muddy Diggings, north of Cassville, then passing N. N. E. to the North Diggings, and then east to the Beetown Diggings, where it expands particularly towards the north, and towards the east shows a bearing to the south-east. This is probably connected with the Pigeon Diggings and other diggings farther east, north of the line of my present exploration. On the south-west, it may be connected with the diggings in Iowa opposite Cassville. 2. That extending from near the mouth of Grant river through the different groups of the Potosi Diggings to the Red-Dog Diggings in a north-easterly (N. N. E.) direction; then east by the Brushhill and Whig Diggings to the Platteville Diggings, where it expands towards the north; and then in an E. S. E. direction through the South-East Platteville and Elk Grove Diggings to the Strawberry

Diggings, where it is interrupted by a wide extent of prairie farther east, in which no ranges have yet been traced. This is probably connected in range with the diggings west of the Mississippi, in a direction south from Potosi, (the Macoqueta and Dubuque Diggings,) which would farther complete it on that side. 3. That commencing near the south line of the State in the Fairplay Diggings, and extending northerly (first N. N. E. then N. N. W.) through the Lower Menominee to the Upper Menominee (Jamestown) Diggings; then bearing E. N. E. through the latter, then shifting north-easterly to the Patch Diggings, then passing E. S. E. to the Buzzard's Roost Diggings, and then bearing south-east to the Shullsburg branch, north of New Diggings. This is probably connected with the Lower Galena Diggings, in the forks of Fever river and the Mississippi, S. S. E. of the Fairplay Diggings. 4. That including the Hazel Green Diggings, which may be traced from those diggings into Illinois, first S. S. W. then S. S. E. to the Upper Galena Diggings (north of Galena.) On its western border, in the Hazel Green Diggings, it bears N. N. E. to the Hoss Diggings, and then curves around to the E. S. E. through the Benton Diggings to Fever river at Benton. 5. That including the Vinegar Hill Diggings, bearing N. N. W. to Vinegar Hill, then north-easterly to Buncomb and Shaw's Hollow, and then easterly through the New Diggings. 6. East of the south-east point of series 3, the E. S. E. direction of series 4 (at Benton) is resumed at Earnest and Spenceley's Diggings on the Shullsburg branch, and continued through the Shullsburg Diggings. These are intersected by the extensive range of North and Souths leading from the East Blackleg (connected with a series of East and Wests on the East Fork of Fever river) through the North and Souths at Townsend's and the Irish Diggings to the East and Wests at Stump Grove, N. N. E. of Shullsburg. 7. A series of small groups may be traced easterly, in a line east from the Strawberry Diggings, through Skidmore's and Halstead's Diggings, by Darlington, to Whiteside's Diggings, whence it bears south-easterly to the Wiota Diggings. 8. Another series, commencing at King's and the

Forked Deer Diggings, west of the West Pecatonica, extends first E. N. Easterly by the Duke's Prairie Diggings to the Yellow Stone Diggings, then through these in a general easterly course to the East Pecatonica, and to Biggs' and the Badger Diggings, and then south-easterly by Shook's Prairie (the Aspen Grove Mine) to Skinner's Diggings and others north and east of Monroe. 9. The diggings at Mineral Point apparently form part of another series, commencing on the south-west at the forks of the West Pecatonica and the Mineral Point branch, and thence bearing N. N. Easterly, but the course of which I have not yet had an opportunity of tracing satisfactorily to the north-east and east. This series perhaps extends by Dodgeville, Ridgeway and the Blue Mounds to Exeter; first bearing N. N. E. to Dodgeville, then east to the Blue Mounds, and then south-east to its termination at the valley of Sugar river.

These series are in some instances connected by intermediate groups. Thus the South-West Platteville Diggings may be considered as intermediate between series 3 at the Patch Diggings and series 2 at the main body of the Platteville Diggings. Other instances will be stated in the details following. In no part of the mineral district examined, have I observed so great a connexion of different series as at Benton and New Diggings, where several seem to concentrate.

The grouping of the East and Wests by their bearings does not correspond strictly with this arrangement in connected series, but has important relations to it. Thus the bearing E. 10° S. prevails through series 1, as far as yet examined, and in the east part of series 2, where it bears E. S. E.; but these two divisions are remote and detached. That of E. 20° S. prevails in the Potosi Diggings in series 2, the Upper Menominee and Patch Diggings in series 3, the Benton Diggings in series 4, and the Shullsburg Diggings in series 6. These extend across the country in a general E. S. E. direction, and include all the diggings in their course, except the south-east point of series 3. The same bearing is observed in the Mineral Point Diggings and in most of the diggings east of the East Pecatonica in Green Co., including those in the east part of series 8. The bearing E. 8° N. prevails in the southwest part of series 2, 3, 4 and 5, presenting one great body of mineral from west to east, the most remarkable and that which shows best the predominance of the East and West ranges. Different ranges are supposed to be continued through the whole extent from the Dubuque Diggings on the west to the Hazel Green Diggings on the east, and even farther, and some are said to have been traced through by survey. At least it may be affirmed that the series formed in nearly an east and west line, by the Dubuque, Fairplay and Hazel Green Diggings, and continued through those at Benton, New Diggings and Shullsburg, is the most connected and regular and in the whole the most productive of any in the mineral district.

Some series of less extent or more interrupted may be traced, conforming in their arrangement to the more extended series, and perhaps indicating the course of bodies of mineral which have not yet been explored. Thus one such may be traced from a group of ranges S. S. E. of Sinsinawa Mound (Gautier's and others,) N. N. E. by Turner's Diggings to the Findley Diggings on the west fork of the Sinsinawa, and to the source of the east fork of the same. The large bodies of mineral recently found at Turner's Diggings would seem to indicate that farther important discoveries may yet be expected along that line. Slighter indications of another such series may be traced, between the Mississippi and the Great Menominee, from Gilbert's and Henderson's diggings, just south of the State line, by Sinipee to the Wolf Diggings, near Dickeysville (Paris,) west of the Jamestown Diggings. These lines of detached diggings, although they may be as yet of little importance, are worthy of notice, in connexion with farther searches for mineral, or as guides for prospecting.

In tracing the different series, it will be found that the different groups succeed each other in a certain order, variously modified indeed, but yet tending to a general system. The following detail will serve better to illustrate the arrangement of the series.

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Thus, following the west border of the first series, it will be found to bear north-easterly from the Muddy Diggings (1 *a*) to the North Diggings (1 *b*,) and then east to the south-west point of the Beetown Diggings, which first present a large group of East and West ranges (the Muscolunge Diggings, 1 *c*,) extending northerly along the east side of Rattlesnake creek. This is marked towards the north by a line of quarterings, bearing north-easterly, at Brown's range, indicating a recession to the north-east. On the south, this group is connected with a group farther east (the Nip and Tuck Diggings, 1 *d*,) in which numerous North and Souths are combined with fewer East and Wests, marking a similar direction to the north. Next succeeds the main body of mineral in this series (the proper Beetown Diggings, 1 *e*,) in the ridge between the Beetown branch and Grant river, and in a position, on the whole, farther north than the two latter groups. The bearing of this is south-easterly; the more northern ranges extending farther west, and the more southern farther east, and this bearing is further marked by quarterings and North and Souths, bearing in the same general direction.* A detached group (Haslett's Diggings, 1 *f*,) N. N. E. of the north-west point of the proper Beetown Diggings, forms the northern limit of this series, and is apparently continued E. S. Easterly in a small group of diggings on the east side of Grant river.†

The series 2 also presents a similar succession of groups. The South Potosi Diggings (2 *a*,) commencing on the east bank of Grant river, near its mouth, extend N. N. E. along the east side of Rigby hollow to the summit between Potosi (Snake) hollow and the waters of the Platte, and from this line bear E. S. Easterly, extending much farther east towards the north than towards the south; the group forming a curve, analogous to that of the entire series, directed towards the Patch and Upper Menominee Diggings. After a considerable interval, another group (Craig's

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*The ranges called North and Souths have here a N. W.—S. E. bearing.

† This last group probably forms a connexion between the Beetown and Pigeon Diggings.

Diggings, 2 *b*) commences at Buenavista, where it is marked on the west by a line of North and Souths, bearing around from S. S. E. on the south to N. N. E. on the north, and limiting the East and Wests in this group on the west. The south-east border of this group is also marked by North and Souths bearing N. N. Easterly. This is followed by a series of groups successively receding to the east towards the north (Coyle's, Rockville, Pinhook and Red Dog Diggings,) the last of which (2 *c*) terminates on the east in a bluff on the west side of the Big Platte. This last group is particularly marked by quartering crevices, indicating a change in the direction of the series to the east. In the interval from the Red Dog Diggings to the Platteville Diggings, only two considerable groups, the Brushhill and Whig Diggings (2 *d*—2 *e*,) bearing nearly east and west, mark the course of the series. The Platteville Diggings (2 *g*) then form an extensive body of mineral, bearing north-easterly from the South-West Diggings (2 *f*) through the line of diggings along the south side of Platteville village, including the three ranges on the Galena road already noticed, to two large groups north of the village, successively receding east. A line of ranges, east of the village, also bears north-easterly from the east point of the group south of the village, extending east, at its north-east point, in a projection crossed by North and Souths. The series is then continued in a direction E. S. E. from the group south of the village, through the South-East Platteville Diggings (2 *h*) to the north-west point of the Elk Grove Diggings (2 *i*) at J. Phillips' farm. The principal groups in the Elk Grove Diggings extend N. N. E. from their south-west point at Hutchinson's Diggings, along the west side of the west branch of Fever river to their north-west point above indicated, and then bear E. S. Easterly to the North Diggings near the Elk Grove and Mineral Point road. A few more isolated ranges lie south of the latter towards Elk Grove village. Farther in the same E. S. E. direction, is a large detached group (the Strawberry Diggings, 2 *j*,) on the east side of the east branch of Fever river, also extending N. N. E.; marked, on the south, by a remarkable change in the direction of the ranges from a south-east to an E. S. E. bearing (that of the ranges in the main body of the group towards the north.) East of this group, there is a wide interval in which no ranges have been discovered. The series 7 commences at Skidmore's Diggings nearly east from the south point of the Strawberry Diggings, and in the direct interval between these, traces of mineral have been discovered at the Light-House tavern, on the Platteville and Shullsburg road, perhaps indicating the passage of ranges along that line.

The next series (3) commences on the south with a very extensive group (the Fairplay Diggings,) extending, along its western border, from its S. W. point near the State line, in a N. N. E. direction, with a series of recessions to the east, most strongly marked towards the north. This may be divided into two subordinate groups, separated by the east and west hollow at Fairplay village. The South group is divided into two parallel series, bearing northerly, in which the ranges generally correspond, but separated by an interval in which most of the ranges are apparently interrupted or have not been followed. The ranges, however, are more connected towards the north; the two series uniting in the ridge south of Fairplay village. The western series (3*a*,) along the east side of the Fairplay branch, was discovered and worked five years before the other, along the west side of the Sinsinawa Mound at the Jamestown Mine.* The most northern ranges and the most southern in the eastern series (3*b*) extend or at least have been worked much farther east than the intermediate ranges. The Northern group (3*c*) projects slightly to the west at its S. W. point, and then recedes to the east, at first more slightly in a number of extensive ranges, and then largely towards the north, where it forms a subordinate group of less extent from east to west, and terminates in a detached range on A. Taylor's farm. From this point the series projects to the N. W.; its course in that direction being marked by three successive groups of East and Wests, crossed by N. West quartering ranges leading towards the west point of the Upper Menominee Diggings. Of these groups, the second (the Lower Menominee Diggings, 3*d*) is the most considerable. The Upper Menominee (Jamestown) Diggings (3*e*,) present a series of East and Wests (bearing E. S. E.,) the most southern commencing farthest west, and the more northern receding successively to the east in groups overlapping each other more or less, the bearing of the whole body of mineral being E. N. E. On comparing the series subordinate to series 3 on the east, the first group will be found S. S. E. from the S. E. point of the Fairplay Diggings; the second, east of that point; the next (Turner's,) nearly east of the subordinate group at the N. E. point of the Fairplay Diggings; the next (Findley's,) nearly east of the Lower Menominee Diggings; and the last (at the source of the east fork of the Sinsinawa,) E. N. E. of the east point of the Upper Menominee Diggings and south of the Patch Diggings. The Patch Diggings (3*f*,) the next in succession to the Upper Menominee Diggings, lie considerably to the N. E. of the latter, in a direction towards the Platteville Diggings, and occupy an intermediate position between them. They consist chiefly of a main body of East and Wests, crossed on the west and east by groups of North and Souths, which serve to mark the limits in those directions. In the interval between the Patch Diggings and the Buzzard's Roost Diggings, in an E. S. E. direction, I have observed only a small group, a little S. E. of the forks of the Platteville and Elk Grove roads. The Buzzard's Roost Diggings (3*g*,) are the commencement of a series of diggings (3*h*,) already mentioned, bearing south-easterly across Fever river to the Shullsburg branch. These diggings are in the lower bed of the upper magnesian and in the blue limestone, principally in the former. They include those along the west side of Fever river to the Missouri branch near Benton, and those between Fever river and the Shullsburg branch to the Benton and Shullsburg road. This is the only instance I have yet observed of such a S. E. direction of the leading ranges. That this direction is not derived from the strata in which the diggings are situated is shown by the different direction of the ranges in the same strata both at Mineral Point and in the immediate vicinity in the dry-bone diggings west of Shullsburg. The Lower Galena Diggings, in the forks of Fever river and the Mississippi, S. W. of Galena, are in a S. S. E. direction from the Fairplay Diggings (conformably to the arrangement observed in series 4 and 5,) but I have not yet traced a direct connexion between them.

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* The diggings in the West series were struck in 1841-2; those in the East, in 1846-7.

Series 4 may be considered as commencing in the Upper Galena Diggings, on the west side of Fever river, adjoining Galena on the N. E. It extends north-westerly from these by Comstock's Diggings to the Camp Ground, west of the Galena and Mineral Point road, whence it bears northerly, west of that road, to the S. W. point of the Hazel Green Diggings, in a series of North and Souths (4*a*,) combined with East and Wests, particularly towards the south. West of this line of North and Souths are several groups, chiefly of East and Wests, extending towards the Sinsinawa river. The Hazel Green Diggings commence near the north point of the line of North and Souths, just mentioned, in the remarkable body of mineral (4 *b*) traversing them in an E. N. E. direction, already referred to. This presents a series of eight groups, shifting successively to the north, or to the left, and extending about two miles, in an almost uninterrupted series, from the S. W. corner of the diggings to Bull Branch, on their eastern border. Two large groups of North and Souths (the northern known as the Phelps lot,) with East and Wests intervening, extend north from the fourth group to a detached group of East and Wests, nearly west of the eighth group. North of the S. W. point of this body of mineral, a large group of East and Wests (the Purdy lot, 4 *c*) projects to the west, and not far N. E. of this a series of North and Souths commences and extends first along the west border of the main body of the diggings to Culver's group, bearing N. N. E., then crosses towards the east side of the diggings (at 4*d*,) and is there continued to their northern border, first bearing N. N. E. and then more directly north. East of this line of North and Souths, before its shift to the east, different groups of East and Wests cross the diggings more or less conformably to the course of the body of mineral on the south. Farther north (at Jefferson village,) a number of large East and Wests, accompanied with smaller, particularly on the east, cross the North and Souths, interrupting and shifting them in their course. Farther north-west, is a series of ranges (Rocky Point and Waterloo Diggings,) bearing more E. N. Easterly, and the whole series is limited in that direction by two detached groups, nearly in line, one of N. N. Easts (the Dutch lot,) west of Culver's group, and the other of E. N. Easts, on the north, (the Hoss Diggings, 4*e*,) in smaller groups successively shifted to the south, marking the turn of the series from north to east.

The body of mineral along the south border of the Hazel Green Diggings is continued in a series of groups, also shifting to the north, through Langworthy's Diggings to Coon Branch (south-west of Benton,) east of which the series is continued in a direction east by south towards the New Diggings. East of the North and Souths at the north-east point of the Hazel Green Diggings, a large group of East and West sheets (the Sheet lot) extends across the high ridge west of Coon Branch towards the Benton Diggings, and is bordered east by groups of North and South sheets (Selkirk's and the Dry-Grove Diggings.) The northern border of series 4 bears E. N. E. from the Hoss Diggings to a small group of East and Wests* not far east of the Platteville road, whence a series of groups extends E. S. E. to the east point of Swindler's ridge (4*f*,) north of Benton village; more interrupted towards the west, and more approximated towards the east. These have been referred to (p. 71,) as shifting alternately to the north and the south through their course. Three parallel lines of ranges, with a similar E. S. E. bearing, occur farther south, towards the Sheet lot, the most considerable of which commences on the west in the Pole range and extends with some interruptions to the diggings at the south end of Benton village (4*g*.)

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* These at their commencement on the west bear E. N. E, and then E. S. E. in a direct line towards the ranges at Swindler's ridge.

Series 5 commences on Fever river near the junction of the east fork (in Illinois,) and extends north-westerly to the south-west point of the Vinegar Hill Diggings, and then north-easterly again to Fever river at Buncomb, forming a well marked curve. This part of the series is marked throughout by a succession of groups advancing west to Vinegar Hill and then receding east to Buncomb, almost uninterrupted in the latter direction, forming there the main body of the series (5*a*,) already referred to as showing the direction of bodies of mineral obliquely crossing the bearing of the ranges (p. 70.) It is also characterized throughout the greater part if not the whole of its extent by groups of North and Souths bordering the groups of East and Wests on the east or west. This arrangement is remarkable as the North and Souths border the East and Wests alternately in pairs on the east and the west; quartering ranges, in a corresponding direction, at the same time marking the shifts of the North and Souths. At Buncomb, the series divides; the most connected portion (5*b*) extending north, up Bull Branch, towards the east point of the body of mineral crossing the south part of the Hazel Green Diggings; the other (5*c*) shifting to the east to the west side of Coon Branch, and then continued north through W. Gillet's diggings to the diggings at Shaw's Hollow, where it approaches the east point of Langworthy's Diggings, above noticed. From this point the series is continued easterly to the New Diggings (5*d*.) In this series, at Buncomb, are two important flat and pitching dry-bone (zinc) mines; one (Coxe's) on the west side of Bull Branch; the other (Gillet's) on the east side of Fever river, opposite the north-east point of the main body of the series just mentioned. The bearing of the ranges in this main body is north of east (E. 8° N.;) that on Coon Branch, south of east (E. 5° S.;) and this bearing is continued in a few groups of diggings between Coon Branch and Fever river leading from the diggings at Shaw's Hollow to the New Diggings, and throughout the latter, which terminate the series on the north-east. The series is most largely developed in the main body on the south-west and in the New Diggings, and even more largely in the latter than in the former. Between the New Diggings and the south point of series 3, there is a large group of East and Wests (the Democrat Diggings, 5*e*,) between Fever river and the Shullsburg branch, in which the bearing of the ranges is E. 10° S., and in nearly the same East—West line, farther east, is the great Dowd and Maginnis range, with several accompanying East and West ranges, (5*f*,) limited on the east by a large North and South (the Ellis range.)

The E. S. E. direction of the ranges at Benton is again resumed on the north side of the Shullsburg branch, east of the south part of series 3, in Earnest and Spenceley's Diggings (6*a*,) in the lower bed of the upper magnesian. This E. S. E. series (6) is continued in the Shullsburg Dry-bone Diggings (6*b*,) in the same bed, and then shifting south across the branch to Townsend's Diggings (6*c*,) is farther continued, with little interruption, through the main body of the Shullsburg Diggings (6*d*,) terminated on the east by numerous North and Souths traversed by a few East and Wests. The diggings in the east part of the series, south of the branch, are in the upper and middle beds of the upper magnesian. They commence, on the west, in large North and Souths, at Townsend's Diggings, which are apparently in the line of the large North and Souths at the East Blackleg Diggings, as already noticed. Then occurs an extensive group of East and Wests, crossed by many North and Souths, some of them extensive, followed by the diggings on the south of Shullsburg village, beyond which are the North and Souths terminating the series. The diggings south of the village have been worked extensively by draining in the middle (flint) bed of the upper magnesian, and have been among the most productive in the whole mineral district. North of the west part of the diggings at Shullsburg village, the Irish Diggings (6*e*) extend from the Shullsburg branch in a series of groups of North and Souths, crossed by a few East and Wests towards the south, successively shifted to the east or to the west, and continued across the summit between the waters of Fever river and the Pecatonica to a group of East and Wests at

Stump Grove, as already noticed. East of the series 6, there are only a few small detached diggings which I have not yet visited.

The next series (7) is of less importance from the extent of the diggings, but is arranged conformably to the prevailing order. I have already noticed its connexion with the east part of series 2. Skidmore's Diggings (7*a*,) the first towards the west, consists of an extensive North and South range or group of ranges, connected with a few small East and West ranges. Next in the series, are two small groups of North and Souths at the head of a branch of the W. Pecatonica, north of Centre, and then two small groups of East and Wests (Halstead's and Read's,) lower down the branch. The line of the series passes by Darlington, and after a long interval the series is resumed in Whiteside's Diggings (7*b*,) a group of East and Wests crossed towards the west by several North and Souths. There is then an interruption in a south-east direction to the Wiota Diggings (7 *c*,) where two extensive lines of East and Wests are closely connected by North and South and quartering ranges. The bearing of the body of mineral is there to the south-east, while the quartering ranges bear north-easterly.

The next series (8) commences on the west in the Forked-Deer Diggings, west of the West Pecatonica. In these diggings, there are at least four parallel lines of East and West ranges, included between Wood's branch on the south, and Bonner's branch on the north. In the south line (8*b*,) along Wood's branch, the diggings are in the blue limestone; in the other lines (8*c*,) in the middle and lower beds of the upper magnesian. The general bearing in these diggings is E. S. E. King's Diggings (8*a*,) on the south side of Wood's branch near the W. Pecatonica, are more detached, and less regular in their bearing; presenting two groups of E. N. E. ranges, one on the north, the other on the south, connected by S. S. E. ranges. The series is continued E. N. E. in the Duke's Prairie Diggings (8*d*,) only a few small and detached diggings intervening, such as Pillins', on the east side of the W. Pecatonica, opposite Bonner's branch, and Scott's, on Otter creek, nearly east of King's Diggings; both in the lower bed of the upper magnesian. The diggings at Duke's Prairie present two principal lines of East and Wests, receding east towards the north, north-east of which, 1—2 miles distant, are two other lines of East and Wests (White's and Graham's,) apparently receding east towards the south. The series is still farther continued, nearly east from the latter, in the Yellow-Stone Diggings, which extend in a general direction nearly east and west, 5—6 miles, from the Yellow-Stone branch to the E. Pecatonica. This line of diggings may be divided into three sections; one on the west 8*e*,) along the north side of the Yellow-Stone, bearing nearly east and west; another extending south-easterly, along the south-west side of McClintock's branch; and a third (8*f*,) bearing nearly east and west from McClintock's branch to the E. Pecatonica. The course of the series farther east is marked only by a few detached diggings, at first bearing more east and west, and then more south-easterly to the diggings north and east of Monroe. The line first shifts to the north to the North Grove Diggings, west of the E. Pecatonica, then to the south to Biggs' Diggings, and again to the north to the Badger Diggings, when it takes a south-easterly direction by the Aspen Grove Mine(8*g*,) Skinner's Diggings and others of less note to a point east of Monroe. South of this line is a short detached series of three groups, east of Argyle, including H. and J. Scott's Diggings, but apparently in the general line of series 7.

The last series (9) I have only partially traced at its commencement on the south-west in the Mineral Point Diggings. These present a series of East and West ranges, more or less grouped, extending from the West Pecatonica across the Mineral Point branch to Rocky Branch, and forming a body of mineral bearing N. N. Easterly towards the diggings at and west of Dodgeville. The general bearing of the ranges is E. S. E. (E. 20° S.) A part at least of the ranges in these diggings are lead-bearing on the west and copper-bearing on the east; the general body of mineral being thus divided, in the direction of its bearing, into two parallel sections. I have not yet traced this series farther north than the Dreadnought Mine, already noticed; but from a hasty view, I have considered it as continued north-easterly to the Dodgeville Diggings, and then in a general easterly direction, through the diggings at Messersburg, Porter's Grove and Ridgeway, to those at the Blue Mounds, when it apparently takes a south-easterly direction to Campbell's Diggings, north of Monticello, and the Sugar River Diggings at Exeter. The last form a group of East and Wests, bearing E, S. E., and at first receding east towards the south, thus forming a body of mineral bearing south-easterly. The most southern ranges, however, appear to recede to the west; the whole body thus forming a curve.

The preceding remarks will serve to show that there is a degree of orderly arrangement in the succession of the diggings, such as to indicate that they are not merely casual deposits, but parts of a connected whole. I have yet been able to make only a general reconnoissance, except in the few localities I had examined before my engagement in the present survey. Farther opportunity would enable me to develope my views in detail.

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It may be interesting to notice the different strata in which the mineral has been worked in the diggings examined by me. As the depth to which mining has been carried on has been generally limited by that of the water level, it has rarely exceeded 100 feet, and has been usually much less; in many instances, only 30—40 feet. Consequently only a small depth of rock has been penetrated in any one instance, and it is thus necessary to judge of the probable downward extent of the mineral by a comparison of different localities, where different strata are brought to or near the surface. This has shown that all the beds of limestone have, in such instances, been found good mineral-bearing rocks, and that the openings succeed each other in regular order, and are connected by vertical veins and mineral crevices, passing from one to the other. When the entire thickness of the upper magnesian is present, the diggings are confined to its upper bed. As the strata become denuded, they commence in the lower part of the upper bed and extend to the middle bed. When the strata are still more denuded, they commence in the middle bed and extend to the lower or through that to the blue limestone, or they even commence in the lower bed and extend through the blue limestone. It is only towards the northern border of the district, where the lower magnesian is exposed in a deep ravine, that I have observed any diggings in that rock.

In tracing the diggings through the different series, it may be stated generally, that in the Muddy and North Diggings mining has been carried on only in the upper bed of the upper magnesian; in the Beetown Diggings, in the upper and middle beds, and adjoining some valleys and ravines, in the lower bed; in the Potosi Diggings, in the same; in the Brushhill, Whig and Platteville Diggings, in the upper and middle beds, chiefly in the latter; in the Patch, South-East Platteville and North Elkgrove Diggings, in the upper and middle beds, chiefly in the former; in the South Elkgrove and Strawberry Diggings, in the middle bed; in the Menominee, Fairplay and Hazel Green Diggings, also in the Dubuque, Upper Galena and Vinegar Hill Diggings, in the upper bed; in the Benton and New Diggings, in the upper and middle beds, chiefly in the latter in the wide flint openings; in the south-east part of series 3, from Buzzard's Roost to the Shullsburg branch, in the lower bed and the blue limestone, chiefly in the former; in Earnest and Spenceley's and the Shullsburg Dry-bone Diggings, in the lower bed; in the rest of the Shullsburg Diggings, generally in the upper bed, but in those where depth has been gained by draining, as in those at the village and at Townsend's, also in the middle bed, at the former in the wide flint openings; in the Blackleg Diggings, chiefly in the upper bed, but in the deep shafts on the large North and Souths, also in the middle bed; in the Wiota Diggings, in the upper and middle beds; in the South Forked Deer Diggings, in the blue limestone; in the North Forked Deer and King's Diggings, chiefly in the lower bed of the upper magnesian; in the Mineral Point Diggings, in the middle and lower beds of the upper magnesian, and in the blue limestone (in the upper and middle beds.) The blue limestone is there reached only in those diggings where the rocks are most denuded, namely, towards the south-west, and adjoining the valleys and ravines; in the more northern diggings (at the Dreadnought Mine,) mining is chiefly confined to the middle bed of the upper magnesian. At Dodgeville, adjoining the village, the diggings are in the upper and middle beds of the upper magnesian; at Duke's Prairie, in the same; at the Yellow-stone Diggings, in the two lower beds of the upper magnesian, and in the blue limestone, chiefly in its upper bed; at J. Scott's Diggings, east of Argyle, in the lower part of the upper magnesian, and at H. Scott's, in the blue limestone; in the other diggings in Green Co., chiefly in the middle and lower beds of the upper magnesian, and in a few instances, as at the Aspen Grove Mine, in the blue limestone. It may be just added, that in the Heathcock range (Linden) the mineral has been chiefly worked in the middle and lower beds of the upper magnesian, but has been recently followed into the upper bed of the blue limestone.

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Copper ores (the sulphuret and carbonate) have been found in large quantity in the mineral district (south of the Wisconsin) only at Mineral Point. Smaller quantities have been found in other localities, particularly at Lost Grove, west of Mineral Point, and 4—5 miles south of Wiota, but these I have not yet visited. I have already noticed the occurrence of small quantities of copper ore in the openings in the middle and lower beds of the upper magnesian, particularly in the middle bed at Shullsburg, and in the lower bed on Fever river, at Buncomb and north of New Diggings. Traces of copper are said to have been found at the Wolf Diggings (west of Jamestown,) in the upper bed.

The copper ores at Mineral Point occur distinct from the lead ore, in ranges apparently in the same East—West line with corresponding lead ranges; the same ranges being lead-bearing on the west, and copper-bearing on the east; the lead and copper ores being at the same time more or less intermixed at the point of junction. There are thus presented two bodies of mineral, lead on the west and copper on the east, bearing N. N. Easterly across the bearing of the ranges. The width of the body of copper ore is apparently 1—2 miles. Both the vitreous and yellow sulphurets are found in the rubbish, more or less accompanied with iron pyrites; but as none of the ranges are now worked, their relative proportion cannot be determined. The earth from the openings has a deeper red tint than that from the lead openings, where such a tint would be considered unfavorable. The arrangement of the body of copper ore, in this instance, across the bearing of the ranges is very remarkable, but corresponds with the general transverse arrangement of the bodies of lead ore, already indicated. The copper has been worked here chiefly in the lower bed of the upper magnesian, but occurs also in the blue limestone.

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I have already observed that the original ores, in the veins and openings in the mineral district, are apparently the sulphurets, namely, of lead, copper, zinc and iron. These ores are more or less subject to decomposition, and to recomposition into other ores; those of lead least, of iron most so.

The sulphuret of lead is chiefly recomposed into the carbonate; the sulphate being rarely observed. The carbonate sometimes forms merely an earthy incrustation on the surface of the sulphuret; but in other instances, the sulphuret is converted to a greater or less thickness, sometimes throughout its entire mass, into the carbonate, still retaining its form unchanged. Sometimes the earthy coat becomes detached and loose, and is then called mineral ashes. In a few instances, the massive carbonate, still retaining the form of the sulphuret, has been found in large quantity, forming bunches in the openings or veins; in one instance, it is said, at Potosi, to the amount of more than 7000 lbs. Crystals of the carbonate are occasionally found, adhering to the surface of the sulphuret, or occupying cavities in it, generally in small quanty, but in some openings more abundant. The largest quantities, I have yet noticed, were in the Aspen Grove Mine, in the blue limestone. The formation of the earthy carbonate on the surface of the sulphuret is apparently going on at present, particularly on the outskirts of the veins. The conversion of the whole or the greater part of the sulphuret to a massive carbonate, and the formation of crystals of the carbonate, appear to be rather the results of former agencies than of those at present operative. The carbonate is called white mineral by the miners, and is more easily reduced than the sulphuret, though yielding a less percentage of lead, but has not yet been found in sufficient quantity to be of much importance.

The sulphuret of copper is recomposed into the sulphate and the carbonate. The former is too soluble and too subject to decomposition to be permanent; the latter generally accompanies the sulphuret as a coating, and sometimes in crystals, but not in sufficient quantity to be important. Both the blue and green carbonate occur, but the latter is most common.

The sulphuret of zinc is recomposed into the sulphate, the carbonate and the silicate; but the former, like that of copper, is not permanent. The carbonate and the silicate are permanent, and are called dry-bone by the miners. They resemble each other, but the carbonate is most common and the most important. They usually replace the sulphuret (black-jack) without much change of form, the general arrangement of the vein or sheet being retained, but the dry-bone being usually less compact, and sometimes apparently stalactitic. In such cases, however, it retains very nearly the original form of the sulphuret, which exhibits too the same botryoidal arrangement. Not unfrequently the interior of the dry-bone is found occupied by the sulphuret unchanged. These recomposed ores of zinc are more abundant in some ranges and openings than in others. The sulphuret of zinc has appeared more subject to decomposition in the lower openings than in the upper; and in the lower openings, it will be found little changed in one range, and mostly converted into dry-bone in another not far distant. The local causes of this difference require farther investigation to determine.

The sulphuret of iron is recomposed into the sulphate and the hydrated oxyd. The sulphate is frequently found in the openings, but like those of zinc and copper, is not permanent, and it results in the formation of the oxyd. The oxyd occurs chiefly in the form of ochre and the brown hematite. The former is generally too much mixed with earth to be of much importance. It gives the peculiar stain to the earthy materials and the rock of the openings. This varies from yellow to red brown, and the distinction of the tints is regarded as of practical importance. A red brown tint is considered by the miners very unfavorable for the occurrence of mineral, and the ground is then said to be burnt.* An orange tint is considered most favorable for lead, and a redder tint for copper. The brown hematite, called iron-rust by the miners, is a very common accompaniment of veins and openings. It occurs in very various forms, from thin sheets and porous slaggy masses to balls arranged in concentric coats with a radiated fibrous structure and botryoidal surface, resembling very exactly the hematite ores of Salisbury (Conn.) and of other ore beds in the same range. That it is formed by recomposition from the sulphuret, without any obvious change of form, is very evident in all the diggings where I have examined it; the sulphuret presenting all its different forms, and every degree of transition being observable from the unchanged sulphuret to the complete change to the hematite; in some instances, only a film of the hematite coating the sulphuret, and the change in others continued gradually to the centre of the mass, sometimes by successive coats, sometimes more by lines from the surface to the centre, some of the radiated fibres being found changed, and others intermixed with them unaltered. Sulphur is occasionally set free by the decomposition of the sulphuret of iron, and is found collected in pockets in the resulting mass. In some instances, calcareous spar occupies cavities in the sulphuret of iron, and on the decomposition of the latter has been found converted into the sulphate of lime. The hematite is sometimes found apparently as perfectly formed as in the Salisbury ore beds, and in such cases would probably yield a superior quality of iron. Care should be taken in selecting such on'y as has been completely recomposed, as the presence of sulphur would injure the product. In some of the diggings, particularly in the openings in the lower bed of the upper magnesian adjoining Fever river, in Benton and New Diggings, large quantities of this ore might be obtained, sufficient perhaps to feed a furnace, and even the ochry earth of the openings might in some cases be rich enough in iron to be reduced to advantage.

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* This merely arises from the abundance of the hydrated oxyd of iron, resulting from the decomposition of iron pyrites.

The earthy black oxyd of manganese (black ochre of the miners) is often abundant in the crevices and openings, and is considered a good indication of the presence of mineral. It is usually found accompanying or imbedding the mineral in the form of a matrix, but is sometimes found filling cavities or geodes in its interior. These facts seem to indicate it of contemporary formation with the mineral, and analogy would lead to the conclusion that its original form was the sulphuret, and that its present form has resulted from the decomposition of the latter. The sulphuret of manganese is said to have been found in the lead mines of Missouri, but I know of no instance in which it has been found in the mineral district.

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The ores of zinc, although very abundant in many instances, particularly in the flat and pitching sheets, and in the lower openings, have never yet been turned to any account. There can be no doubt that they must be hereafter sources of profit, when we consider the large and increasing demand for zinc, both in its metallic form (sheet zinc) and as an oxyd (zinc paint.) The zinc ores found in the mineral district may all be used to advantage. The dry-bone (carbonate and silicate) is most easily reduced, and can be readily converted into the oxyd, and will thus probably be the first to attract attention, but the black-jack (sulphuret) contains the greatest proportion of zinc, and may soon be considered equally available. The proportions of zinc in the three ores are: in the carbonate 51.6, in the silicate 53.12, and in the sulphuret 66.72; that of lead in the sulphuret of lead (galena) is 86.55. The actual product of lead from the sulphuret is considerably less; from average specimens of the ore, about 70. It would not be unreasonable to consider the zinc ores as containing no greater proportion of impurities than the lead ore, and thus the relative product of the pure ores may be properly taken for comparison. The price of zinc is now rather greater than that of lead, in the proportion of about 6 to 7. As soon as an easy connexion is formed between the deposits of the zinc ores in the mineral district and the coal beds in Illinois by means of railroads, it may be reasonably expected that these ores will become objects of importance.

The Galena branch of the Illinois Central Railroad, with the Shullsburg and Mineral Point branches, would open an immediate connexion between the coal mines near La Salle and two of the localities most abundant in zinc ores (that between Benton and Shullsburg, and that at Mineral Point.) Either the fuel might be taken to the ore, or the ore to the fuel, as should be found most advantageous. Other routes of communication would soon be opened, and thus, with American skill and enterprise, a new mining interest would be created, which would compare favorably with the present.

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The leading object of the detail which I have given of the arrangement of the mineral in the crevices and openings in its distribution through the different strata from above downwards, and of the surface arrangement of the ranges in groups and more extended combinations, has been to show that a systematic order prevails throughout, and that the mineral deposits are not detached and casual, but combined in regular series. I might have altered into much more minute detail, but as I have intended this report more as a statement of certain general facts which I conceived were of immediate importance to the mining interest and as an outline of the mode of investigation I have designed to pursue than as the result of a survey, I submit it, such as it is, with the hope that its deficiencies will be excused in consideration of the very brief time in which I have been engaged.

The general result, in relation to the vertical arrangement, is that series of openings containing deposits of mineral are found at certain levels in all the limestone strata from the upper part of the upper magnesian at least to the middle part of the lower magnesian, varying in character in the different strata or beds, but strikingly analagous in the same stratum or bed throughout the whole extent of the mineral district, and that these are combined with vertical crevices and veins or sheets, traceable, where opportunity is offered, from one opening to another, or through different strata when not immediately connected with the openings; that the crevices and openings are distinguished from the adjoining rock by peculiar characters and the presence of substances not found beyond their limits; that they are bounded by regular limits, usually marked by vertical lines, like the walls of veins, as well in the widest flat openings as in the narrower vertical crevices; and that the mineral is arranged in these crevices and openings in a peculiar vein order, more or less evident, but always in some degree distinguishable. The mineral is sometimes arranged in more continuous and uniform sheets; sometimes in more detached deposits or bunches, connected however by mineral seams. These may be considered as the extremes, between which there is a graduated transition, and a more or less intimate connexion. In the upper part of the series, there is a greater tendency to a vertical arrangement; in the middle and lower parts, to a horizontal arrangement, and this increases as we descend, at least to the base of the blue limestone. The arrangement in the lower magnesian appears to commence as in the upper, but the opportunities for examination are there too few to decide satisfactorily, but sufficient to show that the mineral is there arranged conformably to the arrangement in the strata above. The probabilities are thus strongly in favor of a continued descent of the mineral to a lower depth in the strata than is yet ascertained. The appearances seem no less to indicate the origin of the mineral and the accompanying ores from beneath, probably from the primary rocks undelying the lowest secondary; and that they rose in such a condition that they were diffused through a certain definite extent of the materials of the rocks, and then segregated in their present form, and this along certain lines which have determined their arrangement. It would be premature to offer a theory until a more complete exploration had been made, and all the important facts which such an exploration might offer were collected and arranged. But even now I have a strong impression that the mineral has been derived from beneath, and that the prospects of deep and continued mining are here as favorable as in other more established mining districts. The depth to which I have traced the mineral in its regular descent through the strata, assuming their estimated thickness, and including the Upper Sandstone, is 430 feet: Upper Magnesian 240, Blue Limestone 60, Upper Sandstone 60, Lower Magnesian 70 feet; not including the Upper Sandstone, in which no mineral has yet been certainly traced, 370 feet. Including the whole thickness of the Lower Magnesian, rating it at 220 feet, the entire depth would be 580 feet. The order of succession in the strata, at a lower depth, is probably not yet sufficiently settled to determine what further may be expected. I have already enumerated (p.68–9) the series of openings which may be expected in penerating to the base of the lower magnesian. These, not reckoning their subdivisions, may be stated at ten or eleven. The known productiveness of single openings, in many instances, will sufficiently indicate the prospects which such a series would offer to the miner.

The traces of order and connexion in the surface arrangement appear no less remarkable than in the vertical arrangement. What I have here given is only a small part of what might have been stated; but I trust it will suffice to show that the ranges, in their bearing, and in their grouping from the smallest to the most extended combinations, have been governed by some general laws, and have not been merely local accidents. I might have stated many facts which seem to show a regularity in the distance between different ranges in the same group; but such a statement would require a degree of detail incompatible with my present object. Such a regularity is not only probable in the arrangement of each group, but in the combination of groups into larger bodies and more extended series. To determine this satisfactorily would require an exact topographical survey of the mines, which may hereafter become an object well worthy of public attention. The diggings, as they now exist, seem to show a limited extent of mineral bearing lands, only a small part of the surface having been yet broken in search for mineral. That the present diggings represent nearly the surface extent of the ranges yet struck appears not improbable, particularly when we consider the position of the ranges crossing the leading ranges, and apparently limiting their extent. But although the different groups yet worked may have this limited surface extent, it does not follow that all the ranges have been yet discovered. Perhaps diggings as extensive as those yet worked remain still undetected in the wide intervals between the latter, and the indications of such stated in this report (p. 80, 83) may be only a very small part of what yet remain to be discovered. The order which I have attempted to trace in the different series of diggings may serve as a guide in directing farther search, and may lead to such results as will give to prospecting some degree of certainty. Experienced miners have been already influenced by such considerations, and in many instances have found them reliable. The study of the surface arrangement may thus become an important aid to discovery.

# ANNUAL REPORT

OF THE

# GEOLOGICAL SURVEY

OF THE

# STATE OF WISCONSIN.

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BY JAMES G. PERCIVAL.

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MADISON:
CALKINS & PROUDFIT, PRINTERS.
1856.

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# PREFACE.

It appears to have been the design of Dr. Percival to include in this report further remarks under the heads of

The conformation of the surface.

The character of the soils; their agricultural capabilities and connexion with vegetation, particularly forest trees.

The metalic ores.

Minerals useful in the arts and in agriculture.

The surface deposits; and

The effects of primary and ignious rocks upon the lead mines, showing the object of much of his detailed survey under the head of "Surface Arrangement," &c. &c.

# NOTE.

While Dr. Percival was engaged in preparing his second annual report of the geological survey of the State of Wisconsin, he was attacked by a disease which terminated in his death on the 2d day of May, 1856. The unfinished manuscript has been carefully copied and prepared for the press, but it is undoubtedly far from possessing that degree of finish and completeness that would have been given it, had its distinguished author been spared to complete this important portion of his labors,

It is deemed not improper here to insert the following brief obituary notice, taken from the July number of the American Journal of Science, published at New Haven, by Professors Silliman and Dana.

# DEATH OF DR. JAMES G. PERCIVAL.

Died, on the 2d of May, 1856, at Hazel Green, Wis., in the 61st year of his age, Dr. James Gates Percival, eminent as a poet, scholar, and philosopher.

He was born in the village of Kensington, in the town of Berlin, in Connecticut, September 15th, 1795. At an early age he manifested the poetical ability and general intellectual power for which in after life he was so distinguished. He entered Yale College in 1810, but on account of ill health he did not graduate until 1815. During his collegiate course he was eminent for scholarship, although he devoted much time to general studies and to the cultivation of his poetical powers. He studied the profession of medicine, receiving his degree of M. D. in 1820, but he never engaged in the practice. His first volume of poems was published in 1820, his last in 1843. His verse shows great force and freshness of expression, a fertile imagination, and remarkable rhythmical skill. Many of his songs have taken permanent rank in American literature. Chiefly as a poet will he be remembered, but we must here speak of him in other relations.

In 1824 he was for a short time in the service of the United States as Professor of Chemistry in the Military Academy of West Point, and subsequently as a surgeon connected with the recruiting service at Boston. But he preferred solitary study, and gave himself to philological and historical researches, and to general literary pursuits. Having great readiness in acquiring languages, he soon became a critical scholar in most of the modern European tongues, and composed verses in many of them.

In 1827 he was employed to revise the manuscript of Dr. Webster's large Dictionary, and to this work he rendered a service much more important than is commonly supposed. He was from time to time engaged in various literary labors, as editor and translator. Among the works which he published may be named a revised translation of Malte Brun's Geography, and a Sketch of the Varieties of the Human Race, and their linguistic relations, a tract drawn chiefly from the Mithridates of Adelung and Vater, and printed in 1831.

Always an ardent lover of nature, and fond of out-door explorations, he combined with his literary pursuits, the study of natural history and geology. In 1835 he was appointed in conjunction with Prof. C. U. Shepard, to make a survey of the geology and mineralogy of the State of Connecticut. Dr. Percival took charge of the general geology, and explored the whole State thoroughly and minutely on foot. He collected materials for a report so full and extensive that it was thought inexpedient to offer the whole for publication, and he consequently presented only a brief summary thereof. This report was issued at New Haven, in 1842, in an octavo volume of 495 pages, accompanied by a geological map. The work is prepared with great minuteness and precision of detail, but in a manner too much condensed to be very attractive or popular.

He spent the summer of 1853 in the service of the American Mining Company, in exploring the lead mines of Illinois and Wisconsin, and gave such satisfaction to the inhabitants of that region, that the next year he was offered a commission as State Geologist of Wisconsin. His first annual report on that survey was published at Madison, Wisconsin, in January, 1855, in an octavo volume of 101 pages. The larger part of that year he also spent in the field. While engaged in preparing his second report in January, 1856, his health began to fail, and after a few months of decline he passed away.

Dr. Percival possessed intellectual faculties of a very high order, and few men have exceeded him in variety and exactness of learning.

# GEOLOGICAL SURVEY.

To His Excellency Coles Bashford,
*Governor of Wisconsin.*

In presenting my Annual Report on the geological survey of the state, it may be proper to give a brief narrative of my proceedings in pursuing the object of the survey.

The winter (1854–5) had been employed in preparing and attending to the publication of my last report; and after a short visit to the east, which my private affairs rendered necessary, I recommenced my explorations, early in April. I first visited the iron mines, at Iron Ridge, Dodge county, and at Hartford, Washington county, and at Marston, on the Little Baraboo, Sauk county, examining also such other objects of interest as occurred on my route. After this excursion, I recommenced (May 1st) the examination of the lead district, left unfinished the former season, and completed it June 30th. I have employed the remainder of the season, till December 8th, in a reonnoissance of the state, for the purpose of forming a general idea of the geological arrangement. In so doing, I have aimed to traverse as much of the state as possible; and while the determination of the different strata and formations has been my leading object, I have improved every opportunity of visiting such localities as were of particular importance. I have visited in this and my other pursuits, thirty-eight of the fifty counties in the state, all, indeed, except a few of the more nothern and less settled counties. I first made a tour (July—August) through the north-eastern counties as far as Sheboygan, Green Bay and Stevens Point. I then proceeded (September—October) on an excursion through the western counties, north of the Wisconsin, as far as the Falls of St. Croix, and from the want of communication on the Wisconsin side, near the Mississippi, returned on the west side of that river, through Minnesota, from the St. Croix to La Crosse. During November, I made a tour through the south-eastern counties, and thus have been able to take a general view of the largest and, at present, the most important part of the state.

In making this general examination, I have not only had in view objects of direct geological interest, but also the agricultural capabilities of the surface, and have been agreeably surprised to find in the more nothern districts, but a small extent not capable of improvement.

The importance of such a general examination as I have made, however hasty it may have been, will, I trust, be obvious. It has enabled me to form a connected view of the geological arrangement; and in all my observations, should I continue the survey, will furnish me a guide through any difficulties I may encounter. The statements, which I shall make in this report, will, I hope, render similar aid to others who may engage in the same pursuit. I have endeavored to determine with exactness, and believe that the statements I shall make will stand the test of observation. In several instances I have found occasion to differ from the reports of former geologists. I have done so on (to me) satisfactory grounds. A comparison of my statements with those in former reports, particularly as exhibited in the maps, will show you how far I have differed.

Some of these differences will be of much practical importance. Thus the peninsula east of Green Bay has been marked as occupied by the upper magnesian limestone (Owen's Rep. 1852). I am satisfied that it should be marked as occupied by the mound limestone, at the base of which is the position of the Dodge county iron ore. The eastern shore of that bay is thus the line along which that ore may be traced, and from indications already discovered perhaps with success.

The limestones of the upper Mississippi have been referred (Owen's Reports, 1848 and 1852) to the lower magnesian and blue limestone. My observations have led me to consider them as beds subordinate to the lower sandstone. The occurrence of such extensive beds of limestone in that formation offers much additional encouragement to the prospects of deep mining in the lead district. All the different beds of limestone there reached have been found mineral bearing; and if the extensive beds, which I think I have traced in the lower sandstone in the north-eastern counties, should extend, as may be considered probable, beneath the lead district, and there, like the known limestone in that district, should prove mineral bearing, the fild for operations in a downward direction would be largely increased.

A few instances have occurred, where the sandstones, both upper and lower, appear to be traversed by metalic substances, in a manner similar to the limestones in the mineral openings. A remarkable instance of this occurs in the upper sandstone on Skinner's branch, Green county, where the whole depth of the rock is traversed by iron ores, (iron pyrites and oxyds formed from it); and the deposits of copper with iron at Copper Creek, near the Baraboo, and of the brown hematite at Marston, on the Little Baraboo, show a similar arrangement in the lower sandstone.—These facts are encouraging to the prospect of tracing the mineral veins in the lead district through the siliceous strata.

I have ascertained this season that lead has been found in the same strata as in the mineral district, (the upper magnesian, blue limestone, and lower magnesian,) in different places remote from it, toward the north-east, as far at least as the vicinity of Oshkosh, on lake Butte des Morts.

But in these remote localities it has been found only in small quantity, not sufficient to offer present encouragement.

I have examined at different points an extensive range of sienitic rocks, not laid down in former maps and reports, traversing the country from the south side of Fox river through Marquette and Waushara counties, and apparently, from its arrangement, having an important bearing on the phenomena of the lead district, as well as on the general arrangement of the secondery strata, south and east. The extensive ranges of grey quartzite in the Baraboo country and east of Portland have also an apparent connexion with the same.

It is an interesting fact that the principal falls and rapids of the larger rivers in the northern part of the state are formed by the passage of primary rocks. Only a few of the smaller falls and rapids are formed by the passage of beds of limestone. The falls and rapids of the Lower Fox river, are formed by beds of limestone, apparently of the upper magnesian.

In presenting this report, I do not offer the details of my survey, but only such a summary as may be of practical importance. I trust I shall be able to offer many facts in my report on the mineral district, still more encouraging to the prospects of mining in the lower strata; (the blue limestone and lower magnesian,) than those I have offered in my former report. I have been employed this season in examining the more northern mines, which I have found to a large extent—situated in the two upper beds of the blue limestone. Some of the largest and most productive diggings have been there worked in that rock, praticularly those at Black-Jack, Crow Branch, Centerville and Franklin. My observations this season, will enable me to mark with more precision the characteristics and position of the different openings in that rock, as well as in the lower magnesian. As a general result, I am still more strongly persuaded of the probability of continued deep mining, and that by scientifically combining the facts observed in the different diggings, rules may be determined which will enable mining to be conducted with more certainty and less outlay of capital than it has yet been. The probabilities of deep mining, offered by the calcareous beds in the lower sandstone, I have already hinted at.

Next to the lead mines in importance, if not even more important to the ultimate prosperity of the state, are the iron mines. The very extensive beds of lenticular red oxyd at Iron Ridge and Hartford; the deposits of brown hematite found in the counties north of the Wisconsin, particularly at Marston, Sauk county, and the Iron Mountain, Crawford county, the primary ores in the northern districts, particularly those in the vicinity of Black River Falls; and even the Bog Ores, so extensively diffused through the marshes of the state, particularly in the south-eastern counties, offer inexhaustible supplies of that most valuable metal, and in the most important instances, in the vicinity of extensive forests. My examinations have not yet offered me any encouragement for the discovery of coal in the state; and when we consider that the highest known rocks in the state are regarded as the third formation below the coal measures, the probability of such discovery is very remote. Still with the great supplies of fuel in the forests of the state, and the facilities of transportation from the coal-fields toward the south, which the numerous railroads in that direction will ultimately offer, undoubtedly Wisconsin will not only be able to supply itself with iron, but to export it extensively to its neighbors.

The copper mines of Lake Superior I have not yet visited—they must be deferred to another season. But a range of country in the adjoining parts of Crawford and Bad Ax counties, and extending into Sauk county, on the Baraboo, in which copper ores have been found, has lately attracted renewed attention, and may prove of much importance. I have examined several localities in that district, this season, but further researches are necessary to speak with precision of their value.

I have ascertained, this season, I think satisfactorily, the existence of two shell beds, analagous in their fossils, as well as their lithological characters, to the shell beds in the upper part of the blue limestone. They are all particularly characterized by the abundance of shells of the genus *Leptæna*. The first occurs at the base of the blue shale, underlying the mound limestone, and thus immediately above the upper magnesian. It is as largely developed as the Bay settlement on the east shore of Green Bay, ten or twelve miles below the town of Green Bay, and at the iron mine, at Iron Ridge, Dodge county. It is marked in both localities by an abundance of branched corals. It occupies the same position in the strata as the fossiliferous layers called hard-pan, at the base of the blue shale of the mounds, in the mining districts, but differs in its shells. The connexion of the two is formed by the corals, which are also found in the hard-pan. The other is found in the lower sandstone in the country on the Upper Mississippi, and has been regarded by Owen as the same with the shell bed of the blue limestone. It has appeared to me evident that its position is in the lower sandstone, at a higher level than a larger bed of limestone, regarded by Owen as the same with the lower magnesian. This subject will be farther discussed in its place in the report. If these three distinct beds, similar, at least generically in their fossils, but so remote in their position in the strata, shall be fully determined, as I doubt not, they will be, they will offer an interesting fact in fossil history. They will serve, too, as important land-marks in determining the strata less distinctly marked by fossils.

In my present report, I shall first complete my remarks on the mineral district, in the same order as in my last report. I there arranged the facts of most interest and importance under the general heads of stratification, mineral deposits, including the arrangements of the veins and openings in the different strata, and surface arrangement, in which the different diggings were particularly noticed. I shall pursue the same method in what remains to complete the survey of the mineral district. The facts which I have this year collected concur in general with those given in my last report, and add much strength to the views I then presented of the future prospects of mining in that district.

I shall then give the general result of my explorations of the state as far as I have now carried it. I shall first notice the rock formations, both primary and secondary.

I have had opportunity to observe the former class of rocks, only in a few detached localities, particularly at the falls of the northern rivers; still I have noticed the same tendency to grouping in local formations which I have pointed out in my report on the geology of Connecticut. Those rocks, as far as I have observed them in this state, have the most striking analogy to the primary rocks of New England, and if, as distinguished geologists suppose, the two are of remote periods, still the causes which have produced them both must have acted in a manner very nearly if not quite identical. Trap rocks have been noticed in former reports as occurring in different localities which I have visited, but I have not yet observed any rocks which correspond in arrangement, as well as character, with the trap rocks, which appear as intrusive in the midst of rocks of a very different character. The rocks known as trap, at the Falls of the St. Croix, and in the vicinity, are most nearly allied in character to such intrusive trap rocks, but in arrangement more nearly resemble the primary rocks, and might be regarded as approaching the primary greenstones. At the other localities visited, where trap rocks have been indicated, I have observed only horn blendic or sienitic rocks clearly belonging to the primary series. I have not yet seen sufficient reason to regard the primary rocks as metamorphic in their origin. But there are ranges of rocks in the state, in some instances extensive, which are apparently truly metamorphic in their character. That rock which is most obviously so, is a white compact quartz rock, strikingly resembling certain primary quartz rocks, and yet found in larger or smaller masses, as a constituent part of the sandstones, particularly in the lower, in the form either of horizontal beds or vertical dikes. The grey quartz rock, which forms mountain masses in the ridges adjoining the Baraboo valley, and in a tract east of Portland, and which includes minerals characteristic of the primary rocks, although less obviously connected with the sandstones, yet appears to have been really formed from them by metamorphic action. The quartz rocks near Black River, connected with beds of iron ore, has some appearance of a metamorphic rock, but is nearly vertical in position, like the primary rocks in the same district.

The reconnoissance which I have made this season, will enable me to give a general view of the stratification of the secondary rocks, and of the extent of surface occupied by each. The minute detail of the arrangement and distribution of these rocks, can only be obtained by long continued observation; but it is important that rallying points over the whole surface should be early established, so that the particular details may be collected and arranged as they occur, with more facility and a better degree of precision. Detached and remote observations, without such a connecting guide, may lead even experienced observers into error.

The metallic ores, included in the different rocks, both primary and secondary, as well as in the surface deposits, will next be noticed. Their characteristics, as well as their position in the rocks or elsewhere, will be detailed, and such remarks on their importance and economical application as have occurred to me, will be added. Attention will also be directed to the other mineral substances capable of useful application, whether in the arts or in agriculture. The occurrence of gypsum on the peninsula east of Green Bay, in Door county, is here worthy of particular notice.

The surface deposits will form an important section in this report, interesting both in a scientific and economical point of view. For the greater part of the surface traversed, is covered with loose materials; the rock formations occurring usually only in ravines and escarpments, or traversing the beds of rivers. These loose materials appear to have been deposited partly by a drift current acting over the whole surface, partly by local currents along valleys, and partly by sediment from still water, either over an extensive surface, or in limited basins. The boulder drifts accumulated in hills and ridges over the general surface, where it prevails, is uniformly arranged so as to exhibit the action of extensive currents and eddies. A smaller drift of gravel and cobbles is found limited to the valleys of rivers, and appears to have been formed by the action of currents confined to such valleys. The former currents are analogous to those of an ocean; the latter to those of a strait. In the districts where surface is covered by the boulder drift, the surface conforms to the original drift surface, and has only been secondarily modified by washing. In those districts where the surface is covered by deposits from still water, the surface conforms to that produced by washing, and the degree of washing depends on the character of the subjacent rock, or the amount of exposure. Thus there is a greater degree of denudation where the subjacent rock is sandstone, or in the vicinity of valleys and out-crops. The surface of the state, so far as I have traversed it, may be thus divided into two great districts, distinguished by the conformation of the surface, which may be called the Drift and Wash Districts; separated by a line drawn from the St. Croix, in Pierce county, in a general easterly direction, near the falls of the rivers, to the valley of the Wisconsin, and thence south by the head of the valley of Sugar river and Monroe, to the south line of the state near the Pecatonica. The country north and east of this line, belongs to the Drift District, that south and west of it, to the Wash District. This distinction is of importance in an agricultural point of view, the soils in the

Wash District being more closely connected with the subjacent rock than in the Drift District.

I have had in view during my reconnoisance this season, the general character of the soils of the different districts, and their connexion with vegetation. The relations of the different soils with vegetation, particularly with the growth of trees, is of great importance, and should be carefully noted. In this report I shall endeavor to point out the different classes of soils, so far as I have been able to distinguish them by observation, without analysis. Such a preliminary survey is important, in enabling the geologist to make a judicious selection of specimens for analysis, such as will be most extensively applicable to the whole agricultural interest. The state is of such extent, that all that is important cannot be effected at once. Time must be allowed to do all that is needful and desirable well. I trust I shall be excused if after having completed the examination of the Mineral District, which was first required by the act, I have been only able to make such a general reconnoisance as I have made through the more settled part of the state. Analyses of the different classes of soils as well as the different useful minerals, will properly form one of the concluding labors of the survey.

The formation of a cabinet—to be deposited in the state university—will also be one of the objects best attended to towards the close of the survey. Such a cabinet should be selected so as to exhibit most clearly and instructively all that is most impertant to the geology of the state both in a scientific and economical point of view. It is only when the whole ground is surveyed that the geologist can make his selections to the best advantage, and until then the specimens he may collect should justly be under his own care and keeping. I have constantly collected such specimens as I thought would best illustrate the different rocks and minerals in their different localities. Many of these will only serve a temporary purpose, to enable me to connect the different localities. Such as are proper to preserve with others collected for the purpose in those localities which are found best adapted to afford good illustrative specimens, may be combined to form the cabinet proposed.

The collections of fossils will be best effected by the aid of intelligent persons in the vicinity of excavations, such as mines or quarries, who will see that the specimens now and then collected shall be carefully preserved. I am happy to refer to the zealous labors of Mr. Hale, of Racine, in this pursuit, and hope that his example will be followed by many others, who will find in this employment of their leisure not only a high gratification, but that honorable fame which is so dear to us. I need not refer to the labors of Mr. Lapham in this department. They are known to all.

It may be thought by some that a geological survey can be best conducted by numerous local observers, who will each devote himself to the investigation of his vicinity. Such labors are of great importance in completing the details. But the advantage of a survey conducted by one person is the systematic unity which such can best give to the whole. It is only by personally inspecting numerous localities in every section of the state that the connection of the whole can be determined. When the general system is once well ascertained, the details, as they arise, can be adjusted, each in its appropriate place, and an order be established as useful in the common pursuits of life as it is interesting to the man of science. No one can flatter himself, with his best efforts, that he will not leave many things to be added or corrected by others; but an honest devotion to one's duties will doubtless be appreciated and rewarded.

The extent of the state, and the great number of important objects to be investigated, would only enable me, should I continue another year, to give an outline of a full survey. I would hope, for the best interest of the state, that the legislature will consent to the farther continuance of the survey. I do not suggest this from any personal consideration, but from a conviction that such an appropriation, well employed, will more than repay its cost.

Herewith I have the honor of submitting the following report:

Very respectfully,
JAMES G. PERCIVAL,
State Geologist.

# REPORT.

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## THE MINERAL DISTRICT CONTINUED.

In my former report, I gave the result of my examination of the southern part of the mineral district. I have this season visited the more nothern diggings, and have thus completed the examination of the whole. These northern diggings are partly in the upper magnesian, but to a much greater extent than in the southern diggings, in the lower strata, particularly in the two upper beds of the blue limestone. The strata, in these more northern districts, conform very nearly, in their characters, to the same strata in the more southern districts. Such additional particulars, as have occurred to me in relation to them, may be first stated.

## STRATIFICATION.

The effect of the general dip of the strata to the south, in elevating the lower strata, and thereby causing a denudation of the upper, is more obvious in these northern districts, than in the more southern. In approaching the Wisconsin river, the upper magnesian is reduced to its lowest portion, and even this is only found capping the highest points and ridges; the lower strata successively occupying a greater extent of the surface, till at last the lower magnesian forms a belt of some width along the Wisconsin, and the lower part of its principal branches.

The same inequalities in the strata, caused by detached points of elevation, may be also noticed here as in the southern districts. The diggings I have examined this season, are mostly on the northern border of some of the centres of elevation, noticed in my former report, viz., those on the east and west Pecatonica, and on Platte and Grant rivers; on the north or south side of the great divide between the Wisconsin and the streams flowing south to the Mississippi.

Facts observed by me this season seem to indicate that there are points of depression, as well as elevation, in the mineral district. The mounds apparently occupy such centres of depression; the strata dipping in toward them, at least from the north and south, and that at times quite abruptly. The northerly dip from the centre of elevation on Fever river, at Buzzard's Roost, towards the Platte Mounds, was noticed in my former report. A line of depression of the surface extends across the country from east to west, two to three miles north of those mounds, along the south side of which the strata are abruptly elevated, particularly at the south diggings, north of the east mound. A deep valley there extends west from the west fork of the west Pecatonica, on the south side of which the upper sandstone is raised to nearly the same elevation as the upper bed of the blue limestone on the north, and in the middle of which detached bluffs of the sandstone rise to an elevation of at least thirty feet above the sandstone on the north side of the valley, within a short distance. There would seem to have been, along this valley, a line of fracture, with an abrupt elevation of the strata on the south, accompained with a corresponding dip towards the east mound. The Blue Mounds are bordered on the north, at a short distance, by deep ravines, in which the upper sandstone rises to an elevation leaving little room for the strata interposed between it and the mound strata, if their position was horizontal, but which might be explained by a dip towards the mounds.

Some instances of a large dip from outcrops of the lower strata along valleys and ravines have occurred to me this season, marking a sudden elevation at these outcrops. Remarkable instances of this occur on the Mineral Point and Madison road, on the ascent south of the Dodgeville branch, where the upper sandstone dips largely (fifteen degrees) to the south; and at the Crow Branch diggings, where the dip is even greater than in the former instance, and has been traced by running a level from the outcrop of the upper sandstone into the opening in the lower part of the upper bed of the blue limestone (the pipe clay opening,) across the two lower beds of that rock. The irregular position of the upper sandstone in the breaks of the Wisconsin, or the country adjoining it on the south, intersected by deep valleys and ravines, indicates a similar disturbance of the stratification; that rock being found there, within short distances, at very different degrees of elevation. The two knobs north of Ridgeway are remarkable instances of this kind. I have not yet, however, made a sufficiently minute examination of that district to enter into farther details.

## MOUND STRATA.

These I had examined last year in the Sinsinawa mound and the Platte mounds, and have noticed the particulars there observed in my former report. I have this season explored the Blue mounds, and have found there the same general arrangement as in the others, but the upper bed is there apparently wanting, and the middle bed, which in the other mounds is only a limestone, abounding in layers of flint or hornstone, is there composed of a mass of similar flint or hornstone, naturally white or light grey, but generally much stained, red, brown or yellow, by oxyd of iron. This flint contains frequent fossils analogous to those in the corresponding bed in the other mounds, particularly the *Pentamerus*. This remarkable anomaly, by which silex has almost if not quite replaced the limestone of the middle bed, appears peculiar to this locality. The middle bed in the Platte mounds abounds indeed in flint more than that in the mounds farther south and west, and that too, much resembling the flint of the Blue mounds, but in no other part of the country, where I have examined the mound strata, have I observed such an entire conversion of the middle bed to a siliceous mass. This flint bed is confined to the west mound; the east mound, which is much lower, being composed of the lower bed only. This lower bed is here composed of a very light grey, nearly compact limestone, in which fossils are much more rarely observed than in the same bed in the Sinsinawa mound, and closely resembles the corresponding bed in many localities in the overlying limestone on the east side of the state.

The underlying blue shale has been found at different points in the ravines near the base of the Blue Mounds, and in excavations in the same situation, but it has not been penetrated so far as to expose its junction with the upper magnesian and the fossiliferous layers found in that position. These layers are important in connecting the Mound limestones with the overlying limestones on the east side of the state. This connection has been already hinted at, and will hereafter be more particularly noticed in my general view of the stratification of the state.

## UPPER MAGNESIAN.

This formation is less complete in the more northern districts than in the southern. The upper bed is clearly distinguished only near the mounds and in the higher dividing ridges; the surface where the upper magnesian is found, being to a much larger extent occupied by the flint or lower bed. The lower bed rarely shows the brown rock with its disseminated tiff (calc. spar) being usually marked only by the green rock, and the abundance of iron ore (iron pyrites, ochre and hematite), in the openings. The brown rock is well marked only in a series of diggings extending along a line south of Lancaster, between the Beetown diggings on the west, and the New California diggings on the east, including the Pigeon, Grab and Whitaker diggings. Although the middle part of the upper magnesian contains the largest proportion of flints, yet these are found more or less throughout its whole depth, particularly in its lower part, and mark its presence where only a thin cap of it is found on the ridges, towards the Wisconsin, occupied by the lower strata.

### BLUE LIMESTONE.

This formation is much more exposed in the northern districts than in the more southern, and has been there more extensively excavated in mining, and thus offers there a much better opportunity of studying its arrangements. The divisions stated in my former report are there confirmed, and after the examination I have there made of them, can be laid down with more precision than in that report.

The upper bed may be divided into two distinct portions, an upper and a lower. The former is composed of thicker and more uniform layers, yet of a schistose structure, with blue marly seams, and disposed to separate into thinner layers by decomposition. It is sometimes, in its thicker layers, of a distinctly granular structure, like the upper magnesian, and is then subject to disintegrate like that rock, whence it is called sand rock in the more northern diggings. It is much less fossiliferous than the lower portion, and rarely contains any large openings; the mineral being usually found there in thin sheets, horizontal or vertical. This rock too, like the lower part of the upper magnesian, in some of the northern diggings, is sometimes stained green, particularly on its marly seams, by the hydrate of iron, and like that might be called the green rock. The lower portion consists of alternate layers of a harder and purer limestone, either compact or of a peculiar sparry structure, and of a soft bluish marl or shale, and abounds in fossils, forming the proper shell bed of the blue limestone. The most characteristic fossils of this shell-bed are of the genus *Leptæna*. The fossils are chiefly found in the limestone layers, which are sometimes mainly composed of them. The upper pipe clay opening is connected particularly with this lower portion.

The three divisions of the middle bed, noticed in my former report, are generally well characterized in the northern districts. The upper fine, granular portion, forms the cap of the proper glass-rock opening, and it is at the junction of this with the middle compact portion, that that opening is situated. This cap rock is peculiarly subject to a brown stain near that opening, and is hence called the brown rock by the miners. The compact portion forms the floor of the glass rock opening, and in the northern district is preferred for lime, and hence called *limestone*. The lower portion, consisting of thinner layers, with blue marly seams, and of a peculiar compact nodular structure, is usually divided into small jointed fragments. It is not considered proper for lime, but has been used in the manufacture of hydraulic cement, and is usually called *bastard limestone*. It is sometimes found forming a bed of unusual thickness, nearly replacing the middle compact portion. It abounds in fossils like the lower portion of the upper bed, but the most characteristic fossils of the latter are rarely found in it. The lower bed has presented nothing peculiar in the northern districts, nor has any productive opening been yet worked there in it.

### LOWER MAGNESIAN.

This formation, in my former report, was divided into two beds, an upper and a lower; the latter characterized by a greater abundance of flint than the former. I then conjectured the existence of a third bed below the lower of those, corresponding in some degree to the upper bed in its character. My examination of the bluffs on the Mississippi and Wisconsin, near their junction, has confirmed this view. Three distinct beds are there observed; the upper and lower less marked by flint, but containing frequent geodes of chrystalized quartz, a character distinguishing the lower magnesian from the higher limestone strata; the middle marked numerous layers of flint, some of great thickness, particularly one near the upper surface of that bed, the position in which most of the mineral found in the lower magnesian has been discovered. Marly layers and seams, stained green by the hydrate of iron, abound in connection with mineral in this position, as well as with that found in the upper bed.

The upper and lower sandstones not having yet been found productive of mineral, the consideration of them, as well as of the extent of surface occupied by the different strata, will be deferred to the general view of the geology of the state in a subsequent part of this report.

## MINERAL DEPOSITS.

The mineral deposits in the more northern diggings are found in the same strata as in the more southern, as well as in the lower magnesian, but to a less extent in the upper magnesian. As the upper bed of the latter is there generally wanting, except in the vicinity of the mounds, or on the higher dividing ridges, the mineral is more generally found in the middle (flint,) and lower beds, extensive flat openings, like those in the two latter beds, noticed in my former report, such as those of Benton and Shullsburgh, are more rare, and the form most usually observed, in the northern diggings in the upper magnesian, is the kind of openings called tumbling openings, in which the mineral is distributed through the rock of the openings in bunches or pockets and veins; the latter forming connexions between the former, and intersecting the rock in various directions. These openings are so called from the circumstance that that part of the rock included between the more decomposed part of the rock accompanying the bunches and veins, retains nearly its original hardness. and forms loose and detached masses in the more decomposed rock of the openings. Usually the walls of such openings are well defined by vertical seams. Sometimes evenly, at other times more irregularly, the distinction between the softer and more decomposed mineral-bearing rock and the harder bounding rock being quite obvious. These tumbling openings are usually of a greater hight than the regular flat openings, and the mineral is arranged in them more in a vertical position. They are sometimes of much width, even twenty to thirty feet wide, and then appear as a combination of different veins, more or less connected, in the same general openings. The tendency of the mineral to form bunches is general in these openings. These openings usually continue in the same line or vertical plane, with occasional deviations or shiftings; but sometimes branches diverge from them, and in some instances, at a certain distance, take a course parallel to the main openings. These openings are generally east and west or quartering, but norths and souths are sometimes observed of a similar character, forming openings of several feet in width, with chunk mineral arranged in a manner conformable to that in east and west opening. Examples of these tumbling openings may be observed in the upper magnesian in most of the more northern diggings, as at the Blue Mounds, Dodgeville, Pedlar's Creek and Wingville. An example of a north and south of a similar character occurs in the brush range at Porter's Grove. These openings are of the same kind as those described in my former report, as occurring in the neighborhood of Mineral Point and in some of the more eastern diggings, as in those on the Yellowstone, in which the mineral is arranged in pockets or bunches, rather than in regular flat or vertical courses. The peculiar arrangement of the mineral, in these openings, in bunches rarely disposed in even courses, and often connected only by ochry seams, requires a greater degree of skill in working them where the mineral is more regularly arranged. In some instances diggings of this kind have been considered as worked out, which have afterwards yielded to miners, better skilled or more careful in following the slighter trace of connexion, an amount of mineral nearly or quite equal to that obtained by following the more obvious connexions.

Some of the most important ranges in the more northern diggings are formed of a combination of flat and pitching sheets, such as those described in my former report. These as I have there observed, have a greater downward range than other openings, extending with little interruption through different beds and even different formations. They appear in general to form two inclined sheets or courses, uniting at the summit in a common flat sheet, and dipping on either side of a middle bar, much less productive than the two lateral courses, if not quite barren. This middle bar has more or less of an opening character, being often intersected throughout with seams of iron pyrites, with the occasional occurrence of black jack or mineral; the latter sometimes occurring in veins or bunches of workable value. In some instances, the flat and pitching course is composed of only one sheet, but in others, several parallel sheets are combined in one opening ground, and even this difference may be observed in different parts of the same range. Such flat and pitching ranges sometimes are extended in the form of curves or horse shoes, and this arrangement, as far as I have observed, appears to be peculiar to these ranges. The Heathcock range (Linden) noticed in my former report, and the Lathrop range (Dodgeville) on which the engine of Washburn and Woodman is placed, are examples of such curvilinear ranges. The arrangement of sheets of mineral around a central mass or bar, in these ranges, has in some degree a parallel in some more regular east and west openings, in which a similar central mass of iron pyrites or pyritiferous rock forms, as it were, a core to the opening, on the sides of which the bunches and veins of mineral are deposited. Such a pyritiferous mass I have noticed in my former report, as traversing to a considerable extent the middle of the opening at Mr. A. Looney's level, (New Diggings,) and apparently cutting off the mineral. The level has been extended two or three hundred feet farther during the past year, and although the central mass has continued throughout, yet a large amount of mineral has been found adjoining it laterally, particularly on the north. I stated in my former report that the sheet on the south pitch at the west end of the Heathcock range had been traced a few feet into the upper bed of the blue limestone. It has since been followed down to a flat sheet resting on a pyritiferous mass apparently forming the base of a flat opening in the position of the upper pipe clay opening, and similar to the pyritiferous mass sometimes occupying the same position in the flat openings in the lower bed of the upper magnesian. The flat and pitching ranges just noticed, may either present a proper sheet arrangement, or a series of bunches ranged in a similar order; the mineral being, in the one case, more evenly distributed; in the other, more detached. The Heathcock range presents an example of the former arrangement, while the Lathrop range is more disposed to the latter. This last range, like the instances of such flat and pitching ranges, noticed in my former report, has been worked with little interruption from an early period, and is still productive. It was first struck in the upper part of the upper magnesian, and is not yet worked to much extent in the lower bed of that rock.

The greater part of the diggings in the Upper Magnesian, in the more northern districts, are in the lower bed of that rock, and from its great denudation often forms patches, or wide openings immediately beneath the surface deposits, from which the cap rock has been removed. The openings in this lower bed, in these districts, are more usually ochre or clay openings; the zinc or dry-bone openings generally occuring there in the blue limestone. The openings at Wingville are such ochre and clay openings; the ground being usually soft, and the mineral generally either in pockets or bunches, or more uniformly disseminated through the soft ground of the opening. In the former case, it is often large, and in more or less regular forms; sometimes forming geodes, or bosses of connected cubes around a projecting portion of the opening rock. In the latter case, it is usually quite small, and sometimes even, where abundantly disseminated, so small as to be obtained only by washing. Yet in these instances, it will be found, when observed in its original position, to be arranged in the same manner as the larger masses.

The brown rock of the lower bed of the upper magnesian is rarely found in the more northern diggings. Indeed it may be said to be found well characterized only in a range of diggings, already noticed, on an east and west line between the Beetown and New California diggings. In those it occurs in much the same manner as in the localities mentioned in my former report; not only with the peculiar chocolate-brown color of that rock, but more or less filled with disseminated tiff (calc. spar.) The openings in that rock, in those diggings, resemble too the wide flat openings in the same rock in the more southern diggings, but so far as I have observed are without zinc ores, and correspond rather to the ochre openings. The mineral in these wide, flat openings, is chiefly arranged in horizontal courses, one above and another below, but sometimes two in one, or both those positions, with occasional vertical veins or sheets intersecting them. The opening rock is generally much decomposed, and the mineral accompanied with sand or clay; but in some instances the rock is little altered, and so hard as to require blasting.

The opinion expressed in my former report, that the loose material found in the openings and investing the mineral have been very rarely introduced from without, but are the result of the decomposition of the opening rock and of the matrix of the mineral, has been confirmed this season by decisive facts, bearing directly upon it, as well as by the general result of my observations. The clay of the openings, in particular, is often found distinctly stratified, like a shale, and in following the same opening, it may be found to pass intc a hard state, occupying the opening in the same manner as the clay. An interesting example of this kind has recently occurred in the engine shaft at the Jamestown mine. The range is crossed about twenty feet west of the shaft by a cross crevice, west of which it has been very productive in the upper (vertical) opening. In sinking below this upper opening, the rock closed with an ochry mineral crevice passing down, and again opened, first in a small cave like opening, and then in a narrow vertical opening, occupied by a hard slate arranged in distinct horizontal layers, and bounded on each side by an ochry seam, like that traversing the close crevice above. This may be regarded as a matrix in a barren part of the range, and the same might be expected, in following it westward, beyond the cross crevice to the productive part of the range, to be found changed by decomposition to a soft slaty clay investing mineral. In boring from the bottom of the shaft, mineral has been lately struck at the depth of twenty feet, and followed down for eight feet, thus indicating that the same range may be barren in one of its openings and productive in another. This point will be farther considered in a subsequent paragraph. The sand too of the openings may often be traced, in the same range, into a hard limestone, and will be found stratified conformably to the latter. The passage of layers of flints through the soft sand and even the clay of the openings, scarcely at all disturbed in their arrangement, has often occurred to me. Those smooth rounded forms of the mineral, found imbedded in soft materials, particularly in clay, which have been regarded by some as water-worn, have been observed by me, in several instances, in the hard unaltered matrix, differing only in being less coated on the surface by the carbonate. Specimens of the same smooth rounded forms I have myself detached from an unaltered matrix of calcarous spar on the sulphate of barytes. That the mineral, with a few exceptions, where it is found on or near the surface, is in its original position and invested with its original matrix, only more or less altered by decomposition, appears to me without doubt.

North and south sheets, as well as those in other directions, are of frequent occurrence in the more northern diggings, and as in the southern diggings, are more abundant in some diggings than in others, and in some even are predominant, while in others they are nearly or quite wanting. Thus in the Pedlar's Creek, Dodgeville, and Porter's Grove diggings, they are numerous, while in the Wingville and Blue Mound diggings they are very rare. They show the same tendency to grouping in bodies of mineral as in the southern diggings, as stated in my former report. The particulars of this arrangement will be given under the head of Surface Arrangement. The openings in the blue limestone, in the more northern diggings examined this season, are well marked, and have been among the most productive. There are two principal openings; an upper, situated in the lower part of the upper bed; and a lower, in the upper part of the middle bed. Mineral is found in other parts of the blue limestone, but such as is comparatively of little importance.

The upper of these openings (the upper pipe-clay opening of my former report) is at the base of the upper bed, in that part of the bed most abundant in fossils, forming the proper shell bed of the blue limestone. This part of the rock consists of layers of a harder and purer limestone, abounding in fossils, and of a blue marly shale, forming by its decomposition a soft clay, usually stained yellow or brown by oxyde of iron. This clay, in one or more of its layers, breaks in small jointed fragments, and is very adhesive, and is called bull-dung by some miners, whence this opening is called by them Bull Dung opening. This is variable in thickness, sometimes swelling into a large bunch of lenticular form, and at other times thinning out; the course of mineral being then usually replaced by corresponding enlargement of the layers of fossiliferous limestone above noticed, which also thin out as the mineral is again resumed. There are sometimes, however, different layers or courses of mineral, and sometimes the mineral breaks obliquely across the rock, by short flats and pitches, from one horizontal course to another.

The upper opening is of different character from its contents;

the mineral being sometimes more connected with iron ores, (iron pyrites, or the results of its decomposition,) at other times with zinc ores, (black jack, or dry bone,) and at others with clay; thus forming what are called sulphur, black jack or dry-bone, and clay openings. The mineral, in these openings, is rarely evenly arranged, but is liable to enlargement and contraction, or to entire interruption; the accompanying ores (of iron or zinc) in the two former sets of openings, in the latter case replacing it, and sometimes forming solid sheets of great extent and thickness. Vertical or pitching crevices occasionally traverse these openings, sometimes bringing down a sheet of mineral from the upper part of the rock, and sometimes mineral being found in them only as they traverse the opening. Usually the mineral in or near these crevices is larger and more regular in its form than in the flat crevices generally, and it sometimes forms in them geodes at or near the crossing of the opening.

These openings are of the class of flat openings, and are usually of much width, and in some instances, several contiguous parrallel openings are connected by mineral seams, usually carrying only a thin course of iron pyrites, or the results of its decomposition, so as to form one general range of great width. In this manner, different openings are connected together, so as to underlie the whole ground to a width of some hundred feet. The diggings at Black Jack and Crow Branch, offer remarkable examples of such connexion. In these and other instances, these parallel and contiguous openings are of a different character in respect of their contents. Thus at the Black-Jack Diggings, there are three parallel ranges; the two southern most intimately connected in the manner above stated; the northern more remote and less connected. The most southern of these abounds in iron pyrites, although it carries also large interrupted sheets of zinc ore; the middle range abounds more in zinc ore, generally in the unaltered form of black-jack; while in the northern, the zinc ore, nearly equally abundant, is generally in the altered form of the carbonate or dry-bone. At the Crow Branch Diggings, there are three contiguous parallel openings; the courses of mineral in each being connected by thinner seams of iron ores, and the narrow interval of ground between the openings being also soft, so as to give to the whole the appearance of one connected opening. The eastern opening (the bearing of the ranges being nearly S. E.) is here a black-jack opening, the mineral being accompanied, as usual in such openings, by lateral sheets of black-jack, which sometimes interrupt and replace it; the middle, a sulphur opening, the mineral being in the same manner accompanied by iron pyrites; and the western, a clay opening, the mineral being imbedded in a clay matrix, in which more or less of iron pyrites is disseminated, for the most part minutely, but sometimes in more distinct concretions. These openings are more or less affected by undulations from west to east, which are more strongly marked towards the west, where they form a series of large flats and pitches. This is apparently connected with the large dip of the strata towards the east from the out-crop of the upper sandstone, not far west, already noticed.

In some instances, the openings in an extensive group of diggings are formed of a common character, while those of a neighboring but detached group are of a different character. Thus, at Franklin, the openings at the Dry Bone Hollow are quite uniformly zinc openings, with occasional alternations of sulphur openings; while in the Manning and West Point diggings, which form a series to the north-west of the former, the openings are all clay openings, with pure mineral. In one instance in that vicinity, (at the Suddorth diggings, north of the Dry Bone Hollow) a peculiar arrangement occurs, which I have not noticed elsewhere. Two parallel ranges, the northern a dry bone, the southern a clay opening, are met on the west by a dry bone range, which forks towards the east, and approaches each of the two former ranges, but so as to overlap the southern clay range on the south.

Although in the Crow Branch diggings, the clay in the clay opening is more or less filled with disseminated iron pyrites, yet in most instances in the clay openings, the mineral is merely embedded in a stiff yellow pipe clay, derived from the decomposition of a clay stone or shale, and in such cases it is usually found detached and in more regular cubic forms, but sometimes in sheets of connected, flattened cubes or tables, as noticed in my former report. The cubes in the latter case, are usually very small; in the former case, often large, and sometimes variously modified.—Such modifications are also common in the Crow Branch diggings. Although the clay in the pipe clay openings is usually stained yellow or brown, yet sometimes, as in Rosse's diggings, (Linden,) it retains the original blue color of the shale, although in the state of soft clay.

Although the greater part of the mineral yet discovered in the upper bed of the blue limestone, has been found in the large flat opening in its lower portion above described, yet considerable quantities of mineral have been sometimes found in its upper portion, usually in the form of sheets, more or less closely embedded in the rock, but mostly accompanied with lateral seams of ochre or clay. These are found in different positions, vertical, horizontal or inclined, and sometimes are continued down through the whole thickness of the upper bed, or from the upper magnesian, when found overlying it, to the large flat opening in its lower portion; sometimes presenting alternate flats and pitches in the descent, sometimes sending off laterally flat sheets, in the manner of a thin flat opening. The mineral in the upper portion of the upper bed, is usually arranged in this manner, and as the sheets are rarely of much thickness, is comparatively of little importance, but may serve as a guide in leading to the large upper opening. A remarkable example of this arrangement occurs in Imhoff's range, in the Dry Bone Hollow, (Franklin,) where a succession of vertical and flat sheets may be traced down from the top of the rock (the upper magnesian there wanting), to the upper or bull dung opening. These sheets are much larger on the flats than on the vertical pitches, and are accompanied with seams of blue and white clay, with more or less iron rust and ochre. The mineral is here accompanied with lateral sheets of zinc ore (dry bone), particularly on the flats, and terminates below in similar dry bone sheets in the large flat opening.

The glass rock openings, in the northern districts examined this season, are generally situated between the upper fine granular and the middle compact portion of the middle bed of the blue limestone, or more exactly in the lower part of the former. This indeed appears to be the constant position of the proper glass rock openings. In this position is a layer of more decomposible pyritiferous rock, rather analogous to the upper fine granular than to the middle compact portion, accompanied with layers of a black or dark brown shade, decomposing into a soft clay. These openings differ in their contents, like the upper openings above described, forming either dry bone (zinc) sulphur (iron) or clay openings, according to the predominant material of the matrix.—Like the upper openings, they are wide and flat, and usually present a larger course of mineral under the cap, with sometimes another below of a similar character. These are usually connected by cross veins or the one passes into the other in like manner, and sometimes, after a limited distance, separates and returns to its former position. A common arrangement is that of an upper sheet or course of mineral, accompanied with zinc or iron ore as a matrix, or with both, underlaid by a layer of clay, formed from decomposed shale, through which small square (cubic or tabular) mineral is more or less disseminated, presenting the same arrangement as has been noticed in the upper clay openings. This latter mineral is usually of little importance, but is sometimes sufficiently abundant to be valuable as wash mineral. The regular arrangement of the mineral in these openings, in relation to the matrix, is the same as noticed in my former report; the iron and zinc ores lateral, the zinc next to the mineral, the iron to the rock, and the mineral (lead ore) central either forming a continued sheet between the lateral sheets of zinc ore, or geodes or bunches in the enlargements in the course or vein, or disseminated through the matrix. In some instances, besides the central course of larger mineral, lateral courses of small mineral are found, adjoining the rock, but they are still separated from the latter by a thin seam of the matrix, at least by the iron. Clay openings are less frequent in the glass rock openings than those carrying ores of zinc and iron, but occasionally occur. In these there is usually an upper course of larger mineral, underlaid by clay or shale, in which small square mineral is disseminated. The larger mineral is sometimes arranged in a continued sheet, or in bunches, as in the openings carrying zinc and iron, only imbedded in clay and at other times, forms a series of cubes or more irregular lumps, in small pocketsin the cap rock, and is then accompanied more with ochre than clay; but the ochre in such cases is in small quantity, only forming a seam enclosing the mineral. The mineral in the clay openings, however arranged, in more usually in regular detached forms than in the other openings. Occasionally the mineral is found imbedded in calcareous spar, which replaces the other materials of the matrix, particularly in the zinc and iron openings. It is then also more detached and more regular in its form, and sometimes presents those smooth rounded forms, which have been supposed to have been worn by currents of water, but which are found as complete in the solid undecomposed matrix as in the soft clay in which they are more usually found imbedded, only less carbonated on their surface. This is an additional proof that such forms are original, and not the result of the action of water, although their occurrence in a stratified clay, conforming in its arrangement to the adjoining rock and apparently formed from a decomposed shale or claystone, filling the openings and investing the mineral as a matrix, is sufficient evidence of the same fact.

The distance between the upper and glass rock openings varies in different districts, and even in the same mine. Generally it is greater in the more eastern diggings, where they have been worked, than in the more western. Thus in the diggings east of Dodgeville, where the glass-rock openings have been chiefly worked, and the upper openings only incidentally, the distance between them is from eight to ten feet; while at Otter Creek, it is only five or six feet; at Franklin, but two or three feet; and at Centerville, but one or two feet; thus gradually diminishing towards the west. In some instances, in the more eastern diggings, the glass rock opening is seen to rise on a more or less gradual slope, or by a series of flats and pitches, to within one or two feet of the upper opening, and then to recede from it to its former position; and in such cases, the cap is usually broken in mining, and the two openings connected at that point. In some of the Franklin diggings, and in one instace at Centerville, the glass rock opening has been found below the upper opening, separated only by a thin cap of fine granular rock (the upper part of the middle bed,) and the two openings have been marked together, like the upper and lower courses of mineral in the same flat opening. In other instances in the Franklin diggings, and generally in the more eastern diggings, the glass rock opening has been worked separately, and the upper opening, in such cases, has rarely proved productive.

I have noticed, in my former report, an instance of a glass rock opening (at Meeker's Grove) in which the mineral was imbedded in heavy spar (sulphate of barytes) as a matrix. A similar arrangement occurs at the south diggings (south of the black-jack diggings) where several ranges of glass rock openings bear north by west, the mineral accompained in general by iron pyrites and calcareous spar, but in the south part of the two western ranges (on nearly the same east and west line) it is imbedded in heavy spar. This latter forms a layer under the cap rock, more or less enlarging and contracting, or lenticularly arranged, and is bordered by bands of brown shale with small square (dice) mineral disseminated or in thin connected sheets. The mineral is arranged in the heavy spar, much as in the instance at Meeker's Grove, in a larger middle course, forming a connected sheet, enlarging and contracting like the matrix itself and in the thicker portions sometimes forming geodes, or detached, and then in more regular forms. Calcareous spar is also found here and there along the line of the middle course, either interrupting the mineral or imbedding it. Lateral courses of smaller and more detached mineral are also found there as well as at Meeker's Grove. The occurrance of this heavy spar on the same east and west line, crossing at nearly right angles two distinct north and south openings, is worthy of notice.

Contiguous ranges of glass rock openings sometimes present the same differences in their contents as are observed in the upper openings. In the same group of diggings, dry bone and clay openings, or dry bone and sulphur openings, are often found alternating. In a range in the north part of the Lost Grove diggings, near G. Goldthrop's, there are two parallel contiguous east and west glass rock openings; the southern of which is a clay opening, the mineral imbedded in a yellow pipe clay, or in a dark grey, decomposed shale, and usually detached and in regular forms, the northern, in its western part, containing large sheets of iron pyrites, with little mineral imbedded, but towards its eastern part, the iron pyrites is more and more replaced by black jack with an increase of mineral. The mineral, too, is there apparently transferred from the clay opening on the south, to the black jack opening on the north, diminishing in the former as it increases in the latter.

I have not observed any openings worked in the lower bed or buff limestone, in the more northern diggings examined this season.

I had noticed in my former report the occurrence of apparently three distinct openings, in tne lower magnesian; one in the upper bed of the rock, at a small depth below the upper sandstone; another near the upper surface of the middle bed; and a third in the latter bed. My examinations this season have shown that the second of these is the most usual position in which mineral is found in the lower magnesian. It occurs there in connection with a thick bed of flint, or flinty quartz, forming the upper part of the middle bed of the rock, which, when accompanied with mineral, is very cavernous, and stained or coated with iron rust, from decomposed pyrites. This bed of flint, thus stained or coated, is a true mineral opening; the mineral being found in it as it is found in particular layers of rock in the openings in the higher strata along the line of ranges. The arrangement is apparently that of a wide flat opening, in which the mineral is arranged in horizontal order, but usually detached, or in bunches, as it is often in the higher openings, particularly in the flint openings of the upper magnesian. The flint in this bed is arranged in layers, and occupies nearly the entire bed; the layers being only separated by thin layers or seams of marl colored bright green, by the hydrate of iron, and thus differing in tint from the green ores of copper (the carbonate and silicate). These green seams are apparently a constant attendant of the mineral openings in the lower magnesian, particularly of the main flint opening above noticed, and have been observed in all the mineral localities in that rock visited by me, even the most remote. Calcareous spar has been observed by me in connection with the mineral in the lower magnesian, but only in small quantity. The mineral found in the lower magnesian is pure, or only slightly connected with iron ores, and is usually in regular forms, and often in large masses. There has been little search for mineral in the lower part of that rock, and the few attempts at sinking below the main flint opening have been unsuccessful in tracing down the mineral, or in finding a lower opening. The proper mode of working such deposits as occur in that flint opening, is by drifting in them till a vein or well marked mineral crevice is found leading down to a lower level.

The discoveries in the lower magnesian have all been made thus far on the outskirts of the mineral district, at the outcrop of that rock in the vicinity of the Wisconsin, and in the same line north-east. These discoveries in the more remote points of that district have shown that that rock is mineral bearing; but their results should not be held as deciding the mineral character of the rock in the more central parts of the district where it underlies the great openings there found in the upper strata. Deposits of mineral, corresponding to those in the upper openings, may there not unreasonably be expected in the lower magnesian.

The diggings, in the lower magnesian, have all been in ravines and bluffs, at the out-crops of that rock, and have penetrated but a short distance from the surface. They have been rather worked as prospects than as mines, although in some instances large mineral in considerable quantities has been found, particularly in the ravines leading to the Blue river, west of Franklin. Mineral has been observed in that rock here and there along the northern frontier of the mineral district, from the Mississippi on the west, on the north as well as on the south side of the Wisconsin, and in a north east direction, beyond the limits of that district, at Randolph, in the north-east corner of Columbia county, but less far to the north east than it has been observed in the upper magnesian, viz: in the vicinity of Oshkosh. The point of most interest to determine, is the probability of deep mining in the more central parts of the mineral district, and the occurrence of mineral in the lower magnesian at so many points, and, in some instances, in such quantity on its northern frontier, may be regarded as offering no little encouragement to the expectation of finding it in large quantity in that rock beneath the great deposits in the central parts of the district.

Several facts, noticed by me, seem to indicate that the mineral, in its descent, does not always pass directly down from one opening to another, but that in one part of the range it may occupy one opening and then leave it, and in the next succeeding part of the range occupy the next lower opening. This would correspond with the arrangement sometimes observed in the same opening, where the mineral passes from one level to another, by a series of pitches or steps in the direction of the range. An instance apparently of this change of openings has recently occurred at the Jamestown mine, as already noticed. The peculiar arrangement of the two great openings in the blue limestone, where, in some localities the mineral is found in the upper opening, and in others in the glass-rock opening, while the upper opening is found nearly unproductive, appears to indicate a similar transfer on an extended scale. Many instances noticed in my present and former report, show that the mineral sometimes shifts, on the same level, from one range to another parallel range in their progress. These shiftings of the mineral on the same level, or at different levels, are worthy of notice, as if well established and understood, they will lead to more certain methods of mining. The most certain rule in mining, where such shiftings prevail, is to follow the mineral, or those signs which best indicate its course, and whenever an obvious shift occurs, to pursue that, and where the mineral is interrupted, to endeavor to trace its leaders, and always to search for these in such a direction as conforms to the prevailing arrangement in the vicinity. Thus it is known in some diggings that the mineral is liable to shift in a particular direction on the same level, as to the left in the body of the mineral traversing the south part of the Hazel Green diggings. In such cases, when the mineral is interrupted in a range, it may with more probability be found in the direction of the prevailing shift, than in the opposite direction. So where a range which has been worked in an upper opening, approaches a tract where the mineral has been found chiefly in the next lower opening, and is there interrupted, it might with more probability be sought in that lower opening, and traces might be found leading to it.

Although decomposition both of the opening rock and matrix is found to have taken place more or less extensively in most productive openings, yet in some such the rock and matrix are found little changed, and the same occurs more frequently where the rock in the line of such openings, preserves its opening character, but is found barren of mineral, forming a bar in the course of the range. This last circumstance would seem to indicate that the tendency to decomposition is greater in the productive openings, perhaps from the combination of different ores, and their mutual reaction, for in all mineral openings, iron is more or less frequent, originally in the state of pyrites. But in many instances, different ranges, even contiguous, or different parts of the same range, of the same character as to contents, are formed in very different states, one very much decomposed, another very little or not at all altered. This is particularly true of the zinc openings, which when decomposed from dry bone openings, and when unaltered, black jack openings. It is not always easy to determine the cause of such differences. In some instances this decomposition is most strongly marked at the outcrop, and diminishes as the opening recedes from it, and is then obviously caused by the greater degree of exposure to decomposing agents. This is well observed in Topp's range, (Centerville) in which at its outcrop on the south slope of the ridge, the zinc ore was almost entirely in the state of dry bone; as it was carried into the ridge, partly dry bone and partly black jack, the latter increasing until it is now in the state of unaltered black jack. In other instances, the change appears to have been caused by the passage of a vertical or pitching sheet from the top of the rock to the main flat opening. This tendency to decomposition in the mineral openings has greatly facilitated mining, and in those instances where the mineral is small and disseminated through the opening rock or matrix it can be worked to advantage, as wash mineral in a decomposed ground, where it could not be if the ground was unaltered.

### SURFACE ARRANGEMENT.

The surface arrangement in the more northern diggings obviously corresponds to that in the more southern as laid down in my former report. The arrangement there exhibited is rendered more complete by these northern diggings, and on a comparison of the whole, some points of interest which remained not sufficiently certain may be now considered as established. In general the same principle of arrangement, in relation to the combination of ranges into groups, and of groups into more extended series, prevail in the more northern as in the more southern diggings. I shall therefore in the present report, confine myself chiefly to a detail of the different series observed in the more northern diggings, and shall state any peculiarities which may occur in the more particular arrangement in their place in the different series.

The different groups in the more northern diggings are arranged in a number of series as in the more southern. One, (10,) as observed in my former report, may be regarded as a continuation of series 1 of that report, and extends easterly from the Beetown diggings, through the Pigeon, the Grabs, and the New California, and Crow Branch diggings, toward the S. W. point of the diggings in Mifflin N. W. of the Black-Jack diggings. A second series (11) may be traced from the Guttenberg diggings, in Iowa, through the diggings at Ray's Landing and Fenimore diggings to the Wingville diggings, first bearing north easterly and then easterly, corresponding to the course of series 1. This is the most northern series of diggings, if we except the few diggings in the lower magnesian, on the northern frontier of the mineral district. East of the points above stated, there is a remarkable turn to the north in the course of the two series. The second series (11) shifts to the north from the Wingville diggings to the Centerville diggings, and then bears easterly through the Franklin diggings to the Otter Creek diggings. East of series 1 (10,) as traced above, there are a number of parallel lines of diggings, bearing north and north-east to a point east of the Wingville diggings, and the series is then continued east through the Dodgeville and Porter's Grove (Ridgeway) diggings to the Blue Mound diggings. The lines of groups bearing north and north east include the Black Jack and Mifflin diggings (12,) the Lost Grove and Peddler's Creek (Linden) diggings (13,) and the Mineral Point diggings (9,) noticed in my former report, with other minor groups connected with them.

The series (10,) extending east from the Beetown diggings, the different lines of diggings bearing north and north-east (12, 13, 9,) and the series extending east from the Dodgeville to the Blue Mound diggings, may be regarded as one great series, continued from series 1 of my former report, and will be first noticed in detail.

In following this series east from the Beetown diggings, we first meet a number of diggings along the top of the bluffs east of Grant river, on both sides of the Beetown and Lancaster road, and nearly east of the northern Beetown diggings. These are in the lower bed of the upper magnesian, the whole series of strata being exposed in the bluffs from the upper to the lower magnesian, the latter rising a few feet above the water level. These diggings are in ochre openings, and the bearing of the ranges is generally E. S. E. The Pigeon diggings form a more important group on the north side of Pigeon creek, south-west of Lancaster, presenting a number of considerable ranges, generally bearing E. S. E. but sometimes more nearly east and west, with very few north and south or quartering. These two are in the lower bed of the upper magnesian, and generally accompanied with the brown rock with disseminated tiff, and the openings are usually ochre and clay, but in a few instances sand openings; the rock in the latter case light grey, but with disseminated tiff, like the brown rock. Zinc ores have not been found to any extent in these diggings, but a dry bone range has been worked, on the south side of Pigeon creek, in the upper part of the upper bed of the blue limestone. A number of ranges, also bearing E. S. E. occur at the Hurricane settlement, south west of the Pigeon diggings, and east of the south part of Beetown diggings, in a light grey sandy limestone with flints, apparently the flint bed of the upper magnesian, and resembling the prevailing rock in the Beetown diggings. In a line nearly east of the Pigeon diggings, on both sides of the ravine leading to the Big Platte, north-west of Ellenbourough are the Grab diggings, a small group in the lower part of the upper magnesian, in a light grey sandy limestone with flints, the brown rock only rarely observed. These diggings were only recently discovered, but were not worked when I visited them.—They are in a direction N. N. E. of the Potosi diggings, and from this point the series bears north east along the course of the Big Platte to the Whitaker diggings, whence it extends east through the New California and Crow Branch diggings. In this latter part of the series, the general bearing of the ranges is S. S. E. becoming more south-easterly towards the east. The Whitaker diggings are a small group on a high ridge east of the Big Platte, in which the mineral is found in ochre openings at the junction of the upper magnesian, (here a brown rock with tiff and flint) and the blue limestone.

The mineral, too, has been traced down into the upper part of the blue limestone. The bearing of the ranges is here partly S. S. E. and partly east by south. The New California diggings are in a line east of the latter on the ridges on the east side of the valley of the Big Platte, which here bears south-west, and present three principal groups, in an extent of about two miles from west to east. The bearing of the ranges is quite uniformly S. S. E.—The diggings are all in the upper bed of the blue limestone, in the main opening in the lower part of that bed ; the mineral accompanied with clay and ochre, and the rock attending the opening abounding in fossils. These diggings were only recently discovered, but are not much worked at present. The Crow Branch diggings, so called from a branch of the Big Platte, on which they are situated, are in the same line, about two miles farther east, and in the same main opening, in the upper bed of the blue limestone. They may be considered as a single range, more south-easterly in its bearing, and presenting a combination of three contiguous openings, (black jack, sulphur and clay), already noticed. These diggings have been and are still very productive. South of them, at a short distance, is a strongly marked sulphur range in the same opening, and near this, on a higher part of the ridge, is a range presenting an ochre opening, in the lower part of the upper magnesian, bearing S. S. E. Other scattered ranges have been worked on the ridge, further east, in the same part of the upper magnesian, and with a similar S. S. E. bearing. This difference in the direction of the ranges in the different strata, is worthy of notice. South east from the Crow Branch diggings, on both sides of the ravine leading south to the Little Platte, is a small group of diggings in the main opening in the upper bed of the blue limestone; the mineral accompanied both with dry bone and ochre; the bearing in one range south-east, in the others, E. S. E. These groups of diggings east of the Big Platte, are north of the Platteville diggings, and south by west of the Wingville diggings. It was noticed in my former report, that the Platteville diggings form a large group, extending north much beyond the general line of the east and west series, with which they are connected.

The Wingville diggings form a similar extended group in series (11) and nearly half way in a line between them and the Crow Branch diggings, a small group of north and souths (the Iron Rust diggings) in the upper magnesian, form as it were a connecting link between the series 10 and 11. The Platteville diggings are also in the line of the western part of series 3, (former report,) bearing N. N. E. from the Fairplay to the Patch diggings, and series 11 shifts to the north in the same line from the Wingville to the Centerville diggings, thus presenting an extended north and south series transverse to the east and west series. In proceeding eastward in the series, we meet, after a considerable interval, the first line of diggings bearing north and N. east, including the Black Jack and Mifflin diggings. This line (12) extends along the divide between the little Platte and the west fork of the west Pecatonica, and along the valley of the latter. It includes a number of distinct groups, which may be arranged in different subordinate lines. The diggings along the divide and on the upper part of the west fork are in the upper magnesian ; those along the lower part of the west fork, in the blue limestone. The first subordinate line commences in the Burying Ground diggings, on a ridge between two small branches of the little Platte adjoining the divide on the west, and consists of a long series of only two main parallel ranges first bearing E. N. E. and then north by east, shifting to the west near the middle of the latter part of their course. The mineral is in the form of sheets closely wedged in the rock, or in crevices with ochry clay. In a line north east from these diggings, is a large and productive east and west range, (Ludd's,) forming a wide opening apparently in the flint bed of the upper magnesian, east of which is a group of north and south sheet ranges. The bearing of the east and west is E. S. E.; that of the north and souths, north by west. North of this group is another detached group of north and souths, terminating this line on the north.

Another subordinate line may be traced along the divide commencing in a group of diggings south west of Blackjack, composed chiefly of east and wests, bearing both E. S. E. and E. N. E., and crossed by a number of north and souths on the west. W. N. W. of Black Jack is an extensive group of sheet ranges, generally bearing N. N. E., but sometimes E. S. E. or even shifting their course so as to present a curvilinear arrangement. These sheets are generally accompanied with ochre or iron pyrites, and in one instance with black jack, and are apparently in the middle or lower part of the upper magnesian, according to the elevation of the surface. In a line north by east of these diggings, and east of the north group in the first line, is a large detached group (the Tail holt diggings), consisting chiefly of east and wests, forming regular openings or wide patches, crossed by a few north and souths, particularly along the west side of the group. A third subordinate line may be traced along the west fork and the east side of its east branch, in a direction nearly north and south.

This includes first the south diggings (on the west side of the west fork and on the north side of the remarkable east and west valley marked by an extraordinary elevation of the lower strata, already noticed,) consisting of a group of ranges of glass-rock openings bearing N. by W., the two western ranges crossed on the south by a body of heavy spar investing the mineral. North of this are the black jack diggings, among the most important in the mineral district, consisting of three main ranges, already noticed, bearing south easterly, and terminating in the bluff on the west side of the west fork. These are in the main opening in the upper bed of the blue limestone, and are particularly remarkable for the great quantity of zinc ore in the openings. On the east side of the west fork, just north, are a few unimportant east and west ranges worked in the lower part of the upper magnesian, and extending down into the blue limestone. This line is continued up the east side of the east branch of the west fork by a few ranges of little importance, to the Madden range, a large east and west range nearly east of the Tail-holt diggings. These diggings on the east branch are all in the upper magnesian.

The second line bearing north and north-east (13), including the Lost Grove and Pedlar's Creek diggings, extends from a point east of the south diggings, above noticed, up both sides of Pedlar's Creek to the Military road on the divide between the Pecatonica and the Wisconsin. It commences in a large east and west range in an ochre opening in the upper magnesian, on the divide between the west fork and Pedlar's Creek, north east of which a line of diggings in the blue limestone extends along the west side of Pedlar's Creek, generally in the glass rock opening, but in a few instances in the main opening in the upper bed. The ranges generally bear east and west, but in a few instances in the opening in the upper bed, north by west. Nearly opposite these diggings, on the east side of Pedlar's Creek, are the Lost Grove diggings. These are partly in the lower bed of the upper magnesian, on the highest parts of the ridges, and partly in the blue limestone, on the sides of the ridges towards the ravines. The productive ranges in the blue limestone are all in the glass-rock opening, the upper opening being found here of little importance. This group presents on the north, on the north side of a ravine leading west, a long east and west range in the upper magnesian, on the higher ground, and two parallel east and west ranges, lower on the descent and further east, already noticed; the northern, a sulphur range towards the west, and a black-jack range towards the east; the southern, a clay range. On the summit of the ridge south of the ravine, is a large patch in the upper magnesian apparently formed by a wide east and west, crossed towards the west by a similar north and south. On the south side of this ridge, is a large range in the glass-rock opening, in which the mineral is accompanied with tiff and clay, bearing south by east. Other less important ranges occur in this group, both in the upper magnesian and blue limestone. Farther north in the bluff, on the west side of Pedlar's Creek, copper ore (similar to that of Mineral Point) has been discovered in the main opening on the upper bed of the blue limestone, but has not been worked to any extent. Nearly opposite, on the side of the ridge east, is a single vertical sheet range, bearing E. S. E., (the Black Hawk diggings,) and nearly in the same line towards the creek, a range worked to a small extent in the upper bed of the blue limestone. North by west of these, the Pedlar's Creek diggings extend in an almost continuous series from a point nearly west of Linden village to the divide at the Military road already mentioned. They commenced farthest south on the west side of the creek, at an east and west, (the Whym range,) from which extends a line of north and souths, (the Provision lot,) nearly east of which is the Heathcock range, the most southern on the east, and the most important in the whole group.

This last forms a curve, convex to the N. east, and opposite its west end, a line of north and souths extend along the west side of the creek, and then apparently crosses to the east, and is continued in a line of east and wests slightly convex to the north. Throughout this whole extent zinc ores are more or less abundant, while in the other ranges of the group they are rarely met with. From this apparently connected range, lines of north and souths extend along both sides of the creek to a point north of the Franklin road, crossed in a few points by east and wests, particularly at Covel's diggings, in a line nearly east of the Madden range. At the point north of the Franklin road, above mentioned, there is a small group of east and wests, from which the main line of the diggings recedes east to a line of north and souths, which continues more interruptedly to the divide north of the Military road. The diggings throughout this whole group are in the upper magnesian, except at Ross' range, in the line of north and souths, east of the creek, not far north of the dry-bone range connected with the Heathcock range. An opening has there been reached in the blue limestone in the lower part of the upper bed, in which the mineral is imbedded in a soft blue clay. The north and souths form sheet ranges. In the Heathcock range and its connexions, the mineral is arranged in flat and pitching sheets, generally accompained with zinc ores. The east and wests, particularly at Covel's, form large ochre and clay openings, sometimes aboundding in iron pyrites and hematite, (the latter from the decomposition of the former.) A few scattered diggings, are found in the prairies north west as far as Cross Plains, at the crossing of the Franklin and Millitary roads.

A line of diggings parallel to the former may be traced from Diamond Grove, west of Mineral Point, on the ridge west of the east fork of the West Pecatonica, to a point north of the Military road. This commences in a large north and south range (Thrasher's) in the lower part of the upper magnesian. Farther north, beyond a deep ravine, is a group of east and wests, in the same part of the upper magnesian, generally in ochre and clay openings, sometimes forming patches at the surface, from which the cap has been removed. North by west from these, are too small groups of diggings in the blue limestone on opposite sides of the east fork of Pedlar's Creek. Those on the west are in the glass-rock opening; those on the east in the same opening towards the south, and in the opening in the upper bed towards the north. Still north by west, on the ridge west of the fork, is a detached east and west range, crossed and shifted to the north, in its middle part, by north and souths, from which a line of remotely detached north and souths extends to the military road, terminating in a larger group of ranges (the Pump Diggings) bearing around from N. N. E. to E. N. E. These diggings, west of the east fork of Pedlar's Creek, are all in the upper magnesian, north of the Military road, and N. W. of the Pump diggings, is a wide east and west range (Black Davy's,) on a ridge between two ravines leading to the Wisconsin. This range is in the lower part of the upper magnesian, in a rock with green seams and but little flint, resembling the green rock of Mineral Point; and the mineral is either in sheets in the hard rock, or in soft sand or ochre openings. The Otter Creek diggings at the east end of series 11, are N. W. from this point.

From the Dreadnaught range, at the north end of the Mineral Point diggings, as represented in my former report, a series of diggings extends northerly, by Van Meter's survey, to the S. W. point of the Dodgeville diggings. None of these are important, except two large east and wests at the survey. They are all in the upper magnesian, and east and wests till we reach the northern diggings at the survey, whence a line of north and souths extends along the west side of the Dodgeville diggings.

The line of diggings (14) bearing easterly along the divide between the Wisconsin and the Pecatonica, from the Dodgeville to the Blue Mound diggings inclusive, may be considered as terminating the great series continued from series 1, unless it be extended south-easterly to the Sugar river diggings at or near Exeter, as suggested in my former report. The diggings in this line are mostly on the south slope divide, but in a few instances pass north between the ravines leading to the Wisconsin. The Dodgeville diggings commence on the west, in the line of north and souths above indicated, which bears N. N. E. by a series of shifts to the east, to a ridge between ravines leading to the Wisconsin. Another line of north and souths commences on the west of the Lathrop range, at Dodgeville village, and inclines to the west, till it unites with the former towards its northern extremity. This last line is quite uninterrupted in its southern half, and is there crossed on the north and south by east and wests, those on the south connected with the south part of the Lathrop range. This last, the most important in these diggings, forms a curve or horse shoe, first bearing north by west, and then north easterly across a ravine at Washburne's engine. A group of sheet ranges bears north by west, parallel to the south part of the Lathrop range on the east, and apparently crosses the north-east part of the latter. The Dodgeville diggings, thus far, are all in the upper magnesian, commencing on the higher grounds in the upper bed, and extending in the ravines to the lower, but chiefly in the middle flint bed, particularly in the southern east and wests and the Lathrop range. The north and souths are all sheets, usually closely wedged in hard rock; the east and wests as well as the Lathrop range, present tumbling openings, which in the latter are arranged in pitches on each side of a middle less productive bar. Farther east a line of diggings in the blue limestone extends north-easterly from a point about a mile east of Dodgeville to the Holyhead diggings. These are all on the sides of the ravines of different branches which unite to form the Dodgeville branch of the East Pecatonica. They are all apparently in the glass-rock opening, the upper opening not having been found productive. The mineral is generally accompanied with zinc ores, but sometimes with iron or clay. The bearing of the ranges is usually south east, but varies from S. S. E. to E. S. E. presenting remarkable irregularities in their course. North of the Holyhead diggings, is a group of diggings, at Mercersburg, chiefly in the lower part of the upper magnesian. Towards the south, on the ridge west of the Holyhead branch, is a large patch bearing north and south, presenting a flat sheet in the upper magnesian, intersected by a number of north and south vertical sheets. A shaft has been sunk there to a pipe clay opening with square mineral, in the upper bed of the blue limestone. Farther north is a group of north and south sheets in the lower bed of the upper magnesian. This is continued, with some interruptions, to the summit of the divide towards the Wisconsin, crossing a considerable east and west range in its course. On the summit, a ridge east of the south part of the diggings in the blue limestone, are the Norway diggings, a group of east and wests in the upper magnesian. East of these, on the high grounds east of the Holyhead branch, is another large group in the upper magnesian. Those towards the west are mostly east and wests, first bearing E. S. E. and then E. N. E., and are crossed towards the east by a large group of north and souths bearing N. N. W.

Not far east of the group last noticed the Porter's Grove diggings form a considerable group, chiefly on the south of the divide, but extending across it towards the Wisconsin. These diggings are chiefly north and souths, crossed towards the south by a large east and west (the Wakefield range.) There are two large north and souths, (the Firm and Brush leads), the last of which has been followed about two miles, extending far across the divide, and terminating in a flat opening with dice mineral, in the upper bed of the blue limestone. The north and souths carry sheets, except the Brush range, which at the divide forms a wide opening with chunk mineral. These diggings are in the upper magnesian with the exception above noticed. Scattered diggings occur along the south side of the divide between the Porter's Grove and Blue Mound diggings, but none are of interest except a line extending north by east along a ridge about half-way between them. These diggings are apparently in the lower part of the upper magnesian, and are chiefly patches or wide ochre and clay openings near the surface. They commence on the south west at O'Neil's diggings, and extend at intervals about two miles to the military road.

The Blue Mound diggings form a number of distinct groups, south of the Blue Mounds, and are also in the upper magnesian, generally in the flint bed, although in a few instances, at the ravines, mineral has been traced into the blue limestone. The ranges are almost invariably east and west, bearing about east ten degrees south, and usually present wide tumbling openings, which at the ravines, particularly in the more southern ranges, are uncapped, forming patches near the surface. The principal group is at Brigham's range, a large and productive east and west, north of which is another considerable range on which an engine has been recently placed. Dudley's range, south west from this group, is a large detached east and west, and two large east and wests occur at Hawthorn's diggings on the south. Hyde's range, more remote to the S. S. W., is another large range bearing E. S. E. by a series of shifts to the south, the parts of the range having the usual bearing above noticed. A number of less important diggings extend E. S. E. from Brigham's range, about five miles, to Shaw's diggings, a small group of east and wests in the lower part of the upper magnesian. This point is the most remote in the series, unless we include the Sugar River diggings towards the S. E.

Returning west, the series 11, may be traced from its S. W. point towards the N. E. and E. It commences, in this state, in a high bluff on the east side of the Mississippi, at Roy's Landing, S. W. of which are the Guttenberg diggings, on the opposite bank, in a similar situation. This bluff forms a narrow ridge overlaid by a thick bed of the upper magnesian, forming an abrupt wall on the west, below which is a steep slope occupied by the blue limestone and upper sandstone, extending to a low terrace of the lower magnesian at the water's edge. This ridge is apparently traversed by an east and west range, in the flint bed of the upper magnesian, crossed on the east side by a north and south crevice, more productive even than the east and west. The opening is occupied by sand and clay, with much tiff in large masses or disseminated. Small quantities of mineral have been found in the upper part of the lower magnesian, near the Mississippi, one or two miles farther north.

Proceeding north east, we arrive, after a long interval, at the Fenimore diggings, in a line west of Wingville, on the divide between Grant river and the Wisconsin. They consist of two small groups, about two miles apart; one north-west, on the north side of the divide, consisting of two east and wests, the other farther east of one large east and west, by the military road, and others smaller on the north. They are in clay and ochre openings, in a rock with flint, but apparently the lower part of the upper magnesian, and in character resemble the Wingville diggings.

Proceeding east along the divide, by the military road, we arrive at the Wingville diggings, the first of importance in this series. The main body of the diggings crosses the divide east of Wingville village, and extends nearly twice as far from north to south as from east to west. This corresponds with their position in the transverse series extending from the Platteville to the Centerville diggings, already noticed. They are in ochre and clay openings, in a sandy rock with flint, apparently the lower part of the upper magnesian. The ranges are all east and wests, varying from E. N. E. to E. S. E. Black jack has been found here only in two remote points on the west.

Shifting to the north across the valley of Blue river, the series is continued in the Centerville diggings. These are all situated in the main opening in the upper bed of the blue limestone, except in one instance, already noticed, where a lower opening, apparently corresponding to the glass rock opening, has been reached at a short distance below the main opening. They extend from west to east along the ridge immediately north of Blue river, and presents three distinct groups, two west and one east of the village. The ground is these groups is nearly underlaid by contiguous wide flat openings, the apparent direction of which is south easterly, but by successive shifts to the north, in proceeding east, the bearing of the groups varies from E. N. E. so north east. This is particularly observable in the two western groups. The mineral is generally accompanied with zinc ores, more usually in the state of dry bone, with more or less of iron.

The series is continued north-easterly from Centerville to the Franklin diggings, one of the most extensive and important groups in the mineral district. This group is of greatest extent from north to south, and includes a number of subordinate groups, of which the most central, and also the most important, is that at the Dry Bone Hollow, north of Franklin village. These diggings are in the blue limestone, except a few of little importance in the lower part of the upper magnesian, on the higher grounds towards the south, and those in the lower magnesian in the ravines leading to Blue River, west of Franklin village. Those in the blue limestone are chiefly in the main opening in the lower part of the upper bed; the glass rock opening having been worked only in a few instances, as a lower opening, or on the outskirts of the group toward the north and east. The ground in the Dry Bone Hollow, is nearly occupied by contiguous ranges, bearing south-easterly obliquely across the hollow, and worked chiefly in the main opening in the upper bed of the blue limestone, but in a few instances the glass rock opening has been reached only two or three feet below the upper opening, and worked in connection with it. The mineral was first struck on the east part of the ridge adjoining the hollow on the north, in a thin overlying cap of the upper magnesian, where the bearing of the ranges is apparently E. S. E.—This difference in the bearing of ranges in different strata has already been noticed. South of the central group at the Dry Bone Hollow, are only a few scattered diggings; those on the west, adjoining the ravines of Blue River, in the upper bed of the blue limestone; two small groups on the divide, between Blue River and Otter Creek, in the lower part of the upper magnesian, and a range on the east of the divide (Jones'), in the glass rock opening. Copper ore has been found on a line east of Centerville, both in the blue limestone, and one of the two groups in the upper magnesian, that to the south-west. North of the group at the Dry Bone Hollow is an extensive line of diggings from west to east, forming three distinct groups—the Irish diggings on the west, West Point in the middle, and the Suddorth diggings on the east. The general bearing of the ranges is there E. S. E.—These diggings are all in the upper bed of the blue limestone, in the two western groups, in pipe clay openings, on the eastern group, chiefly in zinc openings, but in one of the ranges, in a clay opening. North of the eastern group in this line, after a considerable interval, is a detached group (the Strawberry diggings), on two parallel ridges; on the south, the mineral accompanied with zinc ore in the upper bed of the blue limestone; on the north, with clay and tiff in the glass rock opening. Still farther north, near the point of a ridge towards the Wisconsin, is a small group of diggings in the blue limestone; on the south, in the upper bed, on the north, in the glass rock. This may be regarded as the extreme northern point of the transverse series through Wingville, already noticed. The diggings in the lower magnesian, west of Franklin, are in two ravines leading to Dry Hollow,* one on the west, the other on the east, where that rock underlies bluffs of the upper sandstones. Those on the west were noticed in my former report, and have been worked in the upper, softer bed of the rock, and in the thick layer of flint at the top of the middle bed; those on the east, only in the latter. These diggings have been the most productive yet worked in the lower magnesian.

The series 11 terminates E. S. E. of Franklin in the Otter Creek diggings, in a line towards the most north eastern point of the Pedlar's Creek diggings. These are situated in two ridges between ravines near the head of Otter Creek; the group on the northern ridge at (W. S. Adam's) is the most important. They are chiefly in the glass rock opening, though the upper opening is also present, but has been little productive. The mineral in the glass rock opening is generally accompained with zinc ore, but sometimes with iron or clay. The interval between the two openings is here greater than at Franklin, usually five or six feet. The bearing of the ranges is generally E. S. E., but crossings occur usually bearing south by east.

Mineral has been discovered in the lower magnesian, along the northern frontier of the mineral district, at least as far east as Franklin. At the different localities which I have visited, it has been worked to much extent only in the vicinity of Franklin. Small quantities have been found on the east side of the Mississippi, north of Ray's Landing; on Trout Run, north of Patch Grove; and on the lower part of Green river, near Anderson's saw mill. It has been found in larger quantity on the Little Kickapoo, north of the Wisconsin, in the layer of flints at the top of the middle bed, and like that at Franklin is pure and bright and usually in regular forms; shafts have been there sunk below the flint in which it is found, but it has not been traced downward.

An extensive transverse series, from the Fairplay, through the Platteville and Wingville to the Franklin diggings, has been already noticed. Similar transverse series of less moment, may be traced on the west from the Beetown to the Fenimore diggings, and from the Potosi to the Grab and Whitaker diggings, and on the east from the Wiota, through the Yellowstone, to the Blue Mound diggings, and from Skinner's to the Sugar river diggings. The general bearing of these transverse series is north by east; but the most important of such transverse series is that formed by the g eat body of diggings from Hazel Green to Shullsburg, on the south, the most extensive and connected in the whole mineral district, and that from the Mifflin to the Mineral Point diggings, on the north. These are in the same north by east line of bearing, and both present a number of lines of diggings in the same direction. A large vacant space around the Platte Mounds is interposed between them, and on either side of this, viz: at Meeker's Grove on the south, and at the south diggings on the north, are the most striking appearances of disturbance of the strata by faults yet observed in the mineral district. They traverse too, the middle line of the district, and are as it were, its axis. Their relation to certain appearances of the primary and metamorphic rocks to the north-east will be hereafter noticed. The faults above noticed, are each in the line of a remarkable series of ravines extending for some distance from east to west, perhaps having an important relation to the east and west series.

I have already noticed the occurrence of small quantities of copper ore similar to that of Mineral Point, on the west side of Pedlar's Creek, in the upper bed of the blue limestone, and in an east and west line south of Franklin, in the same bed, as well as in the lower part of the upper magnesian. I have visited this season a group of copper diggings (McKnight's) no longer worked, on the west side of the west Pecatonica, south of Wiota.—The ore consists of the yellow and variegated sulphurets, accompanied with the blue and green carbonate and black oxyd, and is less accompanied with iron than in the more northern diggings.—It is found in vertical sheets or seams traversing the upper fine granular portion of the middle bed of the blue limestone; the sheets enlarging and contracting, sometimes it is said, two inches thick. It is accompanied with calcareous spar, partly fibrous, partly mammillary and composed of minute tables. I have also examined a new range, worked during the past year, in the copper diggings, east of Mineral Point. The ore is the vitreous sulphuret, accompanied with iron pyrites, and more or less changed to the green carbonate. It is found in a soft ochry and clay opening, with seams and pockets of black ochre, and occurs in their seams interlacing the opening ground, or in vertical and flat sheets or small bunches. The copper diggings, at Mineral Point, are not at present in a situation to judge well of their importance.

The ores of zinc in some of the northern diggings are very abundant, particularly in the two great openings in the blue limestone. The largest masses have been found in the main opening in the upper bed at Black Jack, Crow Branch and Franklin; sometimes, where interrupting the mineral, forming solid flat sheets more than a foot thick and of large extent. Very large quantities have been accumulated in the rubbish and piled away in the openings, and could be supplied at little expense of labor; probably large quantities yet remain undisturbed. Zinc works located at points, where the largest quantities of the ore might be easily procured, might well repay investment.

I noticed in my former report (p. 96) the general occurrence of iron ore in the diggings, originally in the state of iron pyrites, but more usually at present in that of ochre or hematite, from its decomposition. These are particularly abundant in the ochre openings in the lower bed of the upper magnesian, as noticed in my former report in such openings in Benton and New Diggings. They are also abundant in some such openings in the northern diggings, where the hematite is observed at times in large masses, apparently fully recomposed, particularly at Wingville. I noticed too, in my former report (p. 18) the common occurrence of seams and nodules of iron pyrites and hematite in the upper sandstone, at its junction with the blue limestone. I have this season observed a remarkable instance where the whole thickness of the upper sandstone is apparently pervaded to a large extent, and in a similar manner, by iron. It occurs on Skinner's branch, near the Pecatonica, in a line S. W. from Skinner's diggings, where a narrow ridge, on the east side of the branch, is composed of a deep red sandstone, more argillaceous than is usual, and including layers of a thin red shale, through which seams and nodules of iron pyrites or hematite, and also of brown iron-stone, are disseminated. On ascending the ridge towards the north-east, this is overlaid by a bed of light grey, indurated sandstone, equally abundant in pyrites and hematite, and underlying the blue limestone. This is the only instance of the kind I have yet observed.

Its position in the line of the transverse series from the Sugar river diggings to Skinner's diggings, is worthy of notice. It perhaps indicates that beneath the ranges in the higher limestone strata, the upper sandstone may be traversed at least by the iron ores accompanying the mineral, leading down to the other deposits of mineral in the lower magnesian.

The facts collected this season, as well as those stated in my former report, show conclusively that all the limestone in the mineral district, from the upper to the lower magnesian inclusive, are mineral bearing. The lower magnesian has been worked only on the confines of the district to the north, nor should the results there be considered as decisive of its productiveness in the central part of the district. The most productive diggings yet worked in it, are those in the vicinity of the important diggings at Franklin, in the blue limestone. The lower sandstone is found to contain extensive beds of calciferous rock, particularly in the north western counties. f these should extend below the mineral district, and from analogy with the other limestones, prove mineral bearing, the chances of deep mining would be much increased. The opinion expressed in my former report that the mineral was derived from beneath, is strengthened not only by the general results of my observations in the diggings, but by the appearance of disturbance in the strata, particularly along the line of the great body of mineral traversing the middle of the district, and by the relation in the bearing of that body to the extensive ranges of primary and metamorphic rocks towards the north east, indicating that the mineral may have arisen from a mass of such rocks beneath the secondary strata. This will be rendered more probable, when I describe the arrangement of these rocks in a subsequent part of this report.

But whatever may be the prospects of deep mining, a large field still remains in the strata which are known to have been productive, particularly in the more southern districts, where the series of strata is more complete. New discoveries are still made in the strata above the water level or easily accessible by draining. The large deposits discovered last winter (1854 5) in Stephen's range, (Shullsburg) and in two ranges in the south part of the Fairplay diggings, and the recent discoveries in the vicinity of Crawford's pump (Hazel Green) below the water level, may be cited as favorable instances. In any attempt at deep mining, those points where the mineral has been found most abundant in the upper openings, should be selected, and care should be taken in sinking, to follow the strongest indications. The shifting of the mineral from one line to another will cause embarrassment, but such is common in the most regular and continued veins, and the regularity and order here observed in this will render the difficulty more easy to obviate. With such evidence of large deposits in the lower strata, it would little accord with the American enterprise to be dissuaded from the search of them by failure of a few attempts, not sufficiently sustained.

### GENERAL RECONNOISSANCE.

I have already stated, in the introduction to this report, that after I had completed the survey of the mineral district, I undertook a general reconnoissance, in which I aimed to traverse as much of the state as possible. In that and my other employments I have traversed more or less than thirty eight counties, all except a few of the more northern.* As I was only five months on my general reconnoissance, I could take only a hasty view of the country, and shall attempt, in this part of the report, only a general outline of the geological arrangement. If I can succeed in fixing a few land-marks, which may serve as stations in the future investigation of details, it will be all that I can expect to accomplish. I might have employed the time in a more detailed examination of a few localities of interest, but my former experience had satisfied me of the great advantage of such a previous reconnoissance in a successful pursuit of the details. I had before commencing it the benefit of a more particular examination of the formations in the mineral district, and as those include all the secondary formations in that part of the state visited, except the lower sandstone, and perhaps a few overlying strata in the west shore of Lake Michigan, I have been able to refer my observations in other parts of the state to the points which I have determined in that district. In giving the results of my reconnoissance, I shall first present a general view of the different *rock formations*, and as the secondary rocks occupy the country generally, where, not covered by the loose surface deposits, the primary rocks appearing only in a few detached points, I shall place them first in order.

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*The counties not visited are Manitowoc, Calumet, Kewaunee, Door, Oconto, Shawanaw, Waupacca, Marathon, Clark, Buffalo, La Pointe and Douglass.

### SECONDARY ROCKS.

The well established secondary formations in the part of the state visited by me are the mound limestone, blue shale, upper magnesian limestone, blue limestone, upper sandstone, lower magnesian limestone and lower sandstone. These are all observed in the country south of the Wisconsin river including the mineral district, but the lower sandstone only at a low level along the valley of the Wisconsin. I have given in my former report and that part of the present relating to the mineral district the results of my observations there in relation to the formations, and shall now give such views of them as are generally applicable, and in particular the extent to which they are distributed over the surface.

### THE MOUND LIMESTONE.*

This formation in the western part of the state is only found overlying a few detached mounds in the mineral district,† as well as the north point of a chain of ridges and mounds east of Galena.* On the west side of the Mississippi it occupies the highlands, an almost unbroken escarpment rising above the level of the upper magnesian, and extending at a short distance from that river, at least from Turkey river southward. It also overlies there some detached mounds, adjoining the highlands, such as Sherald's mound, and Table mound, near Dubuque. The chain east of Galena, above noticed, extends south into Illinois, where it spreads over a large surface, but is much more broken than the high lands west of the Mississippi. On the east side of the State this formation is apparently the overlying rock throughout the whole extent along the west side of Lake Michigan, including the peninsula east of Green Bay, and the islands at its entrance, and extending west to Lake Winnebago. This part of the State, particularly towards the south, is so covered with drift, that with a few exceptions it is difficult to determine there, the western limit of this formation precisely. This formation on the east side of the State is much less elevated than towards the west. On the west it dips with the other strata to the south, or rather to the west of south; but in the east, to the south-east. Between the two escarpments of this formation on the west and east is a wide extent of country where it is wanting, extending south along the course of Rock river into Illinois.

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* This rock has been regarded, from its fossils, as equivalent to the *Niagara limestone.*

† The Sinsinawa mound, on the line of Hazel Green and Jamestown, (Grant county); the Platte mounds, in Belmont (La Fayette county); and the Blue mounds on the line of Dane and Iowa counties.

I have stated in my former report that in the south-western mounds in the mineral district, where the formation is more complete, three distinct beds may be distinguished an upper, abounding in fossils, particularly corals, of which the *Catenipora* may be considered as characteristic: a middle, abounding in flint, and in which too the *Pentamerus* is particularly observable; and a lower, less abundant in fossils, but which may be characterized by a peculiar coral (the *Reticulites.*) In the Patte Mounds, and western Blue Mound, the upper bed is wanting, but the middle bed is there more abundant in flint, and in the western Blue Mound, this even apparently occupies the whole bed, but the *Pentamerus* is there frequent. In the eastern Blue Mound, the lower bed is only present.

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* Terminating in the ridge at Gratiot's grove, south of Shullsburg.

On the eastern side of the State, this formation occurs generally in detached localities, presenting only a small thickness of rock, and it is there more difficult to determine the different beds, than in the south-west. The rock is most exposed in the long line of bluffs extending north from Iron Ridge, along the east side of Lake Winnebago. In that, the lower and middle bed can be distinguished; the lower usually nearly destitute of fossils, but occasionally presenting its characteristic fossil, the *Reticulites*; the middle, less abundant in flint than in the south-west, but marked as there by the *Pentamerus*. At the Bay Settlement, on the eastside of Green Bay, ten or twelve miles below the town of Green Bay, the lower bed is very distinct, marked by its peculiar fossils, and underlaid by the blue shale. The latter also underlies the same bed at Iron Ridge. The *Catenipora*, characteristic of the upper bed in the mounds, is found in the quarries west of Milwaukee, at a low level, indicating a considerable dip of the strata to the east. Specimens of it were shown me at Green Bay, from the highest part of the rock at the Door, and in the adjacent islands. It is found in blocks on the surface in the middle and eastern parts of the district occupied by this formation. Such blocks are frequent on each side of the range of drift hills called the Pots and Kettles, in the western part of Sheboygan county.

The rock of this formation presents a peculiar lithological character by which it may be distinguished from the other limestones. It is usually of a nearly compact grain of a light grey or light cream color, approaching white, is easily dressed, forming, when sufficiently thick, a good material for building, and at times admits of a sufficient polish to be called a marble. This is particularly true of the lower bed. These characters are so very similar in the south-western and eastern parts of the state that the rock can be easily identified. Layers of a thinner compact sub-argillaceous rock of a very even grain, occasionally occur, particularly in the lower part of the lower bed as it approaches the blue shale. Specimens of this from the Door, at the entrance of Green Bay, have been tried and approved for lithographic purposes. An appearance has very generally presented itself in this rock, particularly in the lower beds which I have never observed in any other limestone, and by which it may be distinguished. This is the occurrence of numerous finely grooved seams, which in one instance (on the south fork of Pine Creek, in Kenosha county) were occupied by thin layers of bitumen, but in most instances this is evidently wanting.

In traversing the eastern part of the state I have had but few opportunities of seeing the rock of this formation in place. It is exposed most continuously on its western border towards the north at least as far south as Iron Ridge. South of that point the county is so covered with drift, particularly along the range known as the Pots and Kettles, which may be considered near the western line of this formation, that the rock is exposed only at a few points and those generally at low levels. In its eastern part, through the whole extent traversed, only a few points of rock are exposed, generally in the bluffs and beds of rivers or near the water level on the shore of Lake Michigan. At the entrance of Green Bay, the rock is more elevated, forming high and abrupt bluffs, but that point I have not yet visited. Specimens shown me at the town of Green Bay, prove sufficiently that the rocks there are of the present formation. Immense accumulations of limestone drift (boulders and cobblestone), are found on the surface of this formation, particularly along the line of the Pots and Kettles, generally having the character of its rock, and sometimes distinguished by its peculiar fossils.

The most northern point visited by me is at the Bay settlement on the east side of Green Bay already noticed. Here the rock of this formation forms a low bluff about a mile back from the shore and is evidently the lower bed, marked by the *Reticulites.* It is crossed by a small stream forming a cascade, by which the rock is excavated so as to expose the underlying blue shale. From this the western line of the formation extends S. S. W., east of Depere to Clifton at the north-east corner of Lake Winnebago, and therce south in the ridge east of that lake by Taycheedah towards Iron Ridge. At Taycheedah, where I crossed it, the middle and lower beds may be distinguished, but I did not observe there any fossils. In the long line of bluffs extending from near Mayville to Iron Ridge there is the same deficiency of fossils in the lower bed, but in the middle bed which is seen only in the higher part of the bluffs towards the north, the *Pentamerus* may be distinguished. West of this line of bluffs, blocks of mound rock are found scattered over the surface as far as the east side of Lake Horricon. The lower bed at Iron Ridge, is immediately underlaid by the bed of iron ore which itself is underlaid by the blue shale. At Hartford, though in a line farther east, the lower bed is observed near the rublicon overlying the same bed of iron ore, on the south side of that stream, but on the north side sunk apparently by a fault below its level. The rock is here deficient in fossils as at Iron Ridge, but a pocket of red and white clay was exposed in it, in a cut of the railroad, adjoining which fossils were more abundant. Proceeding south from this I have observed the rock of the present formation in place only at Waukesha, Casselman's quarry in East Troy and Voree near Burlington. In all these localities the rock has the characters of the lower bed, as it is seen in the mounds and ridges towards the Mississippi. It is the same light colored nearly compact rock, easily dressed, and often admitting a good polish, and when sufficiently thick, is a valuable material for building. This is particularly the case at Waukesha and Casselman's quarry where the rock is thicker and firmer. At Voree it is thinner and softer and alternates with layers of shale, and apparently lies near the base of the formation. In all these localities fossils are unfrequent, but occasional layers occur in which they are more abundant. The rock in all these localities is at a low level, raised but a few feet above Fox river, or its branches, to which they are contiguous. Farther south in Wheatland, a large accumulation of blocks was found, on the east side of Lake Nipirring apparently from the breaking up of an underlying ledge, and similar in character to the thicker bedded rock in the preceding localities.

East of the localities above noticed along the apparent line of the lower bed the rock is very rarely exposed until we reach another parallel line near to Lake Michigan. A limestone nearly or quite destitute of fossils is exposed at Sheboygan Falls, at Pigeon river north of Sheboygan, and at the light house near the latter place; in the two former instances little elevated, and in the latter at the bed of the lake. It is in alternate layers, light grey, or nearly white and sub crystalline, and blue, and more compact, and is apparently unlike the rock of the lower bed, and from its want of fossils cannot be readily identified. At Grafton (Ozaukee county) an extensive range of limestone rock is exposed along the Milwaukee river, having the general character of the present formation, the greater part containing very few fossils, but a few layers abounding in them. About three miles north of Racine, at Cooley's and Toes' quarries, beds of limestone rock have been excavated but a few feet, some of the layers of which abound in fossils similar to those at Grafton, and at the rapids of Root river nearly west of these, a similar fossiliferous rock is exposed. In a line between Grafton and Racine, along the Menominee river, west of Milwaukee, a limestone is exposed abounding in fossils, and in which the *Catenipora* is observed. This fossil I have not noticed at Grafton or Racine. This range of fossiliferous limestone, extending north and south from Grafton to Racine, is apparently the upper bed of the present formation clearly identified in the rock west of Milwaukee. The rocks in the vicinity of Sheboygan are in a line farther east and perhaps may form an overlying bed.

### THE BLUE SHALE.

This has already been noticed in my former report, as underlying the mounds, at all of which it has been exposed by excavation. As it is composed of a thin argillaceous slate, readily decomposing into a soft clay, it is always concealed unless thus exposed. The slate itself is apparently without fossils, but at and near its base at the mounds are a few thin fossiliferous and concretionary layers, which are also found in a bed of pipe clay overlying the upper magnesian in different places remote from the mounds. This circumstance was noticed in my former report as indicating an apparent extension of the blue shale over the upper magnesian. This same bed of blue shale may be observed in the eastern part of the state, underlying the mound limestone, where that rock is sufficiently elevated to expose it. Thus it is exposed at the foot of the cascade at the Bay Settlement, and has been found by excavation to underlie the bed of iron ore at Iron Ridge. The resemblance of the rock at these localities to that underlying the mounds is obvious. The position of the bed of iron ore at Iron Ridge is apparently in the upper part of this formation, and in the same position at the Bay Settlement, traces of a similar iron ore may be distinguished. But at the base of the blue shale in the eastern part of the state instead of the few thin fossiliferous layers at the mounds, there is a third bed of fossiliferous limestone very similar to the shell beds in the upper part of the blue limestone, and which might at first be mistaken for it. It abounds like that in shells of the genus *Leptæna*, and in some of its layers is round and flattened branched corals, which are also observed in the shell beds of the blue limestone, but are there much less abundant. The fossiliferous layers in the shale of the mounds differ entirely in their shells from this shell bed, in the eastern shale, but similar branched corals are observed in them, forming as it were a connecting link with the latter. This shell bed extends along the shore of Green Bay at the Bay Settlement, and is found in some of the small streams in that vicinity, evidently at a small depth below the mound limestone. At Iron Ridge it has been found in sinking below the bed of iron ore at the depth of from ten to twenty feet below the latter. It exhibits there the same shells and corals as at the shore of Green Bay.

## THE UPPER MAGNESIAN LIMESTONE.

The character of the rock of this formation in the mineral district has been described in my former report. I have stated there that it most usually occurs partly fine grained and compact, and partly coarse grained and more crystaline, or even with small geodic cavities. These dictinct parts are arranged in a concretionary manner, and as the coarser grained is more decomposible the rock has often a peculiar cavernous appearance.—This character of the rock prevails more or less in other parts of the state where it is distributed. But even the more compact parts of the rock, unless when in very thin layers, exhibit a peculiar subcrystaline grain, by which it may be distinguished from the other limestones. In the mineral district, three distinct beds in this rock may be distinguished, the middle of which is characterized by an abundance of flints, usually arranged in regular layers. The flints in this rock are always in nodules, and compact; crystalized quartz is very rarely observed. Flints, too, are found more or less in the upper and lower beds of this rock, particularly the latter, and in this it contrasts strongly with the underlying blue limestone. In the lower bed in the mineral district, the rock is sometimes observed of a dark brown color (the brown rock), and at other times marked with green seams (the green rock), but is then only stained with iron, usually in connection with mineral openings. This rock is not abundant in fossils, although in some of the thinner layers, particularly at the junction of different beds, they are more frequent. The honey-comb coral (*Coscinopora*) is the most distinctive fossil of this formation, and so far as I have observed, is confined to it. It was in this rock that mineral (lead ore) was first found, and in the more southern diggings, it has been worked almost entirely in it; but in the more northern districts, the blue limestone is equally productive.

The upper magnesian is the overlying rock throughout the greater part of the country in the south-western part of the state south of the Wisconsin, and west of Sugar river, forming the mineral district. It is there little interrupted towards the south and west, but towards the north and east is more broken and denuded. The subjacent strata are observed towards the south and west only in the valleys of the rivers, but towards the north and east they occupy a greater extent of the surface, the upper magnesian there appearing only on the higher ridges. It is from the valleys of the rivers that the denudation of the upper strata has proceeded, and while these have only been broken through towards the south and west, exposing the lower strata in the bluffs, they have been removed to a greater or less extent towards the north and east, the strata receding from the valleys in successive terraces from the lowest to the highest. Some exceptions to this general statement occur in the interior of this district, caused apparently by elevations of the strata at different centres noticed in my former report. Such centres of elevation were there pointed out on Fever river, at Meeker's Grove, on the West Pecatonica, at Mineral Point, on the East Pecatonica, at Argyle, on the Big Platte, at Ellenborough, and on Grant river. At these centres of elevation the lower strata are more exposed, and occupy successively receding terraces in the manner above indicated, but to a much less extent than on the north and east of the district. In addition to the above, I have noticed this season a remarkable line of elevation along the north of the Platte Mounds, from the west fork of the West Pecatonica, at the South Diggings, along the Little Platte, apparently leading from the centre, at Mineral Point, towards that at Ellenborough, and corresponding to that towards the south, on Fever river, at Meeker's Grove; also a centre of elevation on the West Pecatonica, south of Wiota, where the lower magnesian is exposed, and another on Skinner's branch, near its junction with the Pecatonica, including the remarkable locality of ferruginous sandstone noticed in a former part of this report. The upper magnesian has been broken through on the Mississippi, from Dunleith northward; on the Big and Little Platte and Grant river, from their mouths nearly to their sources; on Fever river from near Meeker's Grove, on the north, to near Galena on the south; on the different branches of the Pecatonica, from near their sources south into Illinois. It will thus be perceived that the greater extent of surface where it is unbroken, is in the tract extending north between the Mississippi and Fever rivers, then east between the centre of elevation on the latter river and the Little Platte, then south between Fever river and the West Pecatonica. Another extensive tract where it is unbroken, extends between the Mississippi and Grant rivers, including Blake's Prairie, and a third along the divide south of the Wisconsin, from the valley of Sugar river by the Blue Mounds, to the head of Pine Fork, a branch of Grant river. These two latter tracts are there separated by a narrow break through the lower sandstone connecting the valley of Pine Fork with that of Green river, a branch of the Wisconsin.

The remarks which have been made above on the successive denudation of the strata, will apply to the different beds of the upper magnesian; the upper being most denuded towards the north and east, and around the different centres of elevation This circumstance is of importance in mining, as showing the extent of mineral rock, and the probable number of openings which may be expected in any locality. It is known that as we approach the north, or the centres of elevation, the diggings are found successively in the lower beds of the upper magnesian, and finally of the blue limestone. The details of this have been given already in connection with the mineral district.

Beyond the district, south of the Wisconsin and west of Sugar rivers, the upper magnesian occupies a less extent of surface.

On the north of the Wisconsin, it overlies the summit of the ridge between the Mississippi and the Kickapoo, for a few miles towards the south. Between Sugar river and Rock river it may overlie some of the higher ridges and prairies towards the south line of the State, such as the high ridge between Sugar river and the valley at Footsville, and the high prairies west of Janesville. I have only observed these on the road from Monroe to Janesville, and on the west side of the former found the upper sandstone so elevated as to leave little room for the upper magnesian, while the summit was so covered as to conceal the rock. On the west side of the latter are several quarries of blue limestone, the highest apparently near the junction of the upper magnesian, leaving room on the higher summits for that rock, but these were so covered with drift, that it was not observed. East of Rock river, the upper magnesian occurs in the sides of a higher prairie south of Rock Prairie, where it is quarried at different points near Emerald Grove, east of Janesville. This prairie extends from this point south-west towards Beloit, of the same elevation, and is partially occupied by this rock. North from this, I have next observed it in a number of quarries on a group of low ridges south of Bark river near Fort Atkinson. Near the tops of the ridges it contains frequent layers of flints, but near the base these were not observed, and the thicker bedded rock is there accompanied with thin marly seamed layers, closely resembling a rock frequently occurring at the rapids of the lower Fox river. The rock in all of these localities east of Rock riuer, has distinctly the characters of the upper magnesian, its sub-crystaline grains and its flints, and also its peculiar fossil, the *Coscinopora*. It is quarried there for building, and in its upper flint-beds near Fort Atkinson, for lime. The next point towards the north, where I observed the upper magnesian, was at two quarries north of Watertown, on the road to Oak Grove. It there contains flints, and like the corresponding rock near Fort Atkinson, is burnt for lime. The upper magnesian then extends by Hustisford and Oak

Grove, and the west side of Rolling Prairie, east ot Fox Lake to Waupun. It lies throughout this extent at a low level, generally concealed by drift, and has been exposed only to a slight depth by quarries. At Waupun it terminates in a low bluff towards the west fork of Rock river, but underlies a large extent at a few feet from the surface. The rock in this part of its course is harder and firmer than further south, and is well adapted for building. The State Prison at Waupun is built of this material. The surface of the rock, wherever its covering of drift has been removed, has been found smoothly polished and marked with scratches bearing north east. This rock, though deviating somewhat in its character, is still clearly identified with the upper magnesian by its peculiar fossil, the *Coscinopora*, which is here of general occurrence. A range of drift hillocks, chiefly composed of fragments of limestone, apparently the upper magnesian, as it here occurs, extends in a north-easterly course across Rolling Prairie. These fragments, as well as the rock in the quarries, are burnt for lime.

The extent of the upper magnesian as far as Waupun along the line above indicated may be considered as clearly determined.—Its precise extent from east to west, I have not been able to determine, but it may be considered as occupying the space between the western line of the mound limestone on the east and the range of the blue limestone on the west, which will be afterwards pointed out. It appears to extend from west to east at least from the vicinity of Fox Lake to the east of Lake Horicon. Farther to the north east its course is less clearly identified. The rock in the line of its direction, at and near Oshkosh, and along the Lower Fox river, to Duck Creek, north of the town of Green Bay, although differing considerably from that farther south, and although I have nowhere observed in it the *Corcinopora*, has yet presented throughout rather the character of the upper magnesian than of the other limestones. Two varieties are observed here more particularly; one a very hard, nearly compact thicker rock, with blue marly seams, covered more or less with figures which have been considered fucoidal, but which appear to me obviously concretionary, there being a want of regular recurring forms and of internal organic structure; the other marked by a peculiar parallel structure as if composed of very thin marly seamed layers, firmly cemented, but without the peculiar concretions of the other.—These varieties although more strongly marked here have yet been observed farther south in the upper magnesian. Very few fossils have been found in the rock on the Lower Fox river, and these so far as I have noticed are common to the upper magnesian. The upper magnesian if thus continued will extend in a regular course very nearly north to Lake Butte des Morts and Oshkosh, and then more north-easterly along the lower part of Fox river parallel to the western line of the mound limestone in that part of its course. The shell bed along the east side of Green Bay, which I have identified with that at Iron Ridge, underlying the mound limestone, will thus be found in its true position above the upper magnesian. The shell bed in the blue limestone will be traced along a line west of Fox river.

### THE BLUE LIMESTONE.

The character of this formation, and of the different beds into which it may be distinguished, has been given in detail in my former report, and that part of this report relating to the mineral district. It has not the same uniformity of character throughout as the upper magnesian, the different beds being easily distinguished. I have described three different beds of which the two upper may be divided into distinct portions. The upper bed consists of an upper and a lower portion, the latter highly fossiliferous and forming the upper shell bed of this formation. This shell bed, like that underlying the blue shale is peculiarly marked by shells of the genus *Leptæna*, but contains few of the corals so abundant in the latter. It is in connection with this shell bed that the main upper opening in the blue limestone is situated. The middle bed may be divided into three portions, but of variable thickness, one sometimes to a certain extent replacing another.—The upper fine granular portion forms the cap rock of the glass rock opening. The middle compact thick bedded portion forms the glass rock of most miners. The lower, compact, thinner and more marly seamed portion is the most fossiliferous part of the formation next to the shell bed above noticed, but is rarely marked by *Leptœniœ.* It sometimes replaces to a large extent the middle portion. The lower bed or buff limestone is more uniform in its character, except near its junction with the upper sandstone, where marly and sandy, and sometimes oolitic layers occur.—Throughout the whole extent to which I have traced this formation, these distinctions may be observed more or less obviously, as far as the rock is present, for in some instances the upper part of the rock has been removed. This rock in the mineral district has been mineral bearing as well as the upper magnesian, and in the northern diggings, as productive, particularly in its two main openings.

The blue limestone nowhere occupies such an extent of surface as the upper magnesian. In the country south of the Wisconsin, and west of Sugar river, it forms only narrow terraces on the north and east towards those rivers, and in some instances around the centres of elevation already noticed, or occurs underlying the upper magnesian in the bluffs of rivers and ravines. On the Mississippi it appears underlying the upper magnesian, from Dunleith northward, but nowhere extends back from that river, except on its branches and in ravines, till we approach the Wisconsin. On the lower part of the Big and Little Platte, and Grant rivers, it is generally confined in the same manner; but on the upper part of those streams, around the centres of elevation above noticed, it extends farther back, occupying a portion of surface adjoining the main valleys. This is particularly observable around the head of Pine fork (Grant river), south of the break through to the Wisconsin, already noticed, on the Big Platte, Near the New California and Crow Branch diggings, and on the Little Platte, south-east of the latter, north of the highest point of elevation on those rivers. On Fever river, the blue limestone is exposed throughout the whole extent that the upper magnesian is there broken through-but is confined to the immediate vicinity of the river and its branches. It extends in that manner along the Shullsburgh branch nearly to Shullsburgh. It entends in the same manner along the Pecatonica and its branches, but recedes farther around the centres of elevation noticed at Mineral Point, south of Wiota, and at Argyle and Skinner's branch. The lower strata have indeed been so elevated in the country drained by the Pecatonica, that the blue limestone may be traced along its numerous branches nearly to their sources, and at some points besides those above enumerated, is exposed to a larger extent than usual. This may be observed on the lower part of Pedlar's Creek, and on the west fork at the south diggings, along the supposed line of elevation, north of the Platte Mounds, and also on the Dodgeville branch, east of Dodgeville, at the numerous diggings in the glass rock opening.

North of the Wisconsin the blue limestone overlies the sides of the ridges between the Mississippi and the Kickapoo towards the south where the summit is occupied by the upper magnesian, and extends to the top of the bluffs east of Prairie du Chien, where the middle and lower beds may be distinguished. North of the upper magnesian it overlies the summit, at least to the iron mountain, north of which it only forms caps of more or less detached ridges or mounds of the upper sandstone, extending chiefly along the divide, but in a few instances on the sides of the main ridge. It caps those ridges or mounds nearly as far north as Viroqua, beyond which they are composed only of the upper sandstone.—The arrangement of these ridges will be explained in connection with the upper sandstone. Only the lower bed of the blue limestone is usually present in the caps of these ridges.

In the wide valley of Sugar river the blue limestone only forms caps of mineral detached ridges, usually rising in bluffs in the middle of the valley, and in these caps also, only the lower bed is usually present. Sometimes the summits of these ridges from a considerable plateau covered with a fertile soil. A group of such ridges occurs north east of Dayton, and another adjoining the village of Decatur on the north-west. A range of country traversed by the blue limestone passes around the head of Sugar river on the north and extends across the south part of Dane county, and the north part of Rock county to Rock river, or rather to the western line of the upper magnesian east of that river. The blue limestone does not here overlie the entire surface, but forms caps of the higher ridges, while the lower swells are composed of the upper sandstone. In some of the higher capped ridges all the beds of the blue limestone may be distinguished, and in other lower ridges only the lower bed. The rock, particularly in the middle and lower beds, is often quarried for lime and building. South from this tract the blue limestone is exposed along the sides of the high prairie ridges west of Rock river, particularly on the west side; namely, the ridge between the valley of Sugar river and that at Footville, and the ridge between the latter valley and Janesville. On the west side of the former ridge it overlies the upper sandstone at a high level, but on the west side of the latter it lies lower, and all its beds may be distinguished. In the vicinity of Janesville it appears in low bluffs along Rock river, particularly at the Monterey quarries on the south, and in the west bank of the river about two miles north. In both these it overlies the upper sandstone, but at a higher level in the bluff towards the north. At Monterey the three different beds may be distinguished. The lower bed, although chiefly stained buff, is in some layers marked by its natural blue color, and as in other localities is well adapted to building, and even admits of a polish like marble. Turning north, the blue limestone is apparently the overlying rock, through a wide tract extending from Rock river at Lake Koshkonong to the vicinity of the Third Lake at Madison. At Lake Koshkonong it sinks to the water level, but on Koshko.

nong Creek and other streams farther west the upper sandstone is largely exposed. This part of the country is extensively covered with drift, but the blue limestone is found at many points, near the surface, particularly on the prairies where the drift is usually less accumulated. Farther north, this tract extends to the east side of Sun Prairie, where the blue limestone may be observed overlying the upper sandstone. As we proceed north in the direction of this tract, the country is so covered with drift that few opportunities occur for observing the blue limestone. It occurs, however, north-west of Portland where the lower bed is found overlying the upper sandstone, and south west of Columbus where it appears along an extensive range, the upper sandstone exposed only by excavation, and in some points, as at Allen's quarry, the two lower beds well marked. In that quarry small quantities of lead have been found particularly in the middle bed. The line of direction of the blue limestone continued north would pass by the west side of Fox Lake, but I did not there observe it. It appears, however, in the escarpment along the east end of Green Lake, overlyiag the upper sandstone at a high level, and bearing around to the east, occurs in a similar position above the sandstone at the quarries at Ripon and Ceresco, on the east and west sides of the deep valley passing through the latter. At these quarries the middle and lower beds can be distinguished. North of this its course has already been indicated to me, by a thin layer overlying a low detached ridge west of Waukau composed of the upper sandstone resting on the lower magnesian, which there underlies the surface generally. A well marked specimen of the shell-bed of the blue limestone was shown me at Appleton from the town of Freedom, north of Kaukauna, indicating the course of that rock near the divide between Fox and Wolf rivers.

## THE UPPER SANDSTONE.

This rock has been described in my former report, as it occurs in the mineral district. It has exhibited nearly the same characters wherever I have observed it, and my observations this season have presented but few peculiarities worthy of notice. The most remarkable is that occurring on Skinner's branch, noticed in the former part of my report, where nearly the whole thickness of the rock is colored deep ore by oxyde of iron, and nodules of iron pyrites and hematite are disseminated throughout. This dissemination of iron is common in this rock, at its junction with the blue limestone, but in no other instance have I observed it in this manner pervading the whole. This rock is generally composed of uniform fine grains of quartzose sand, usually very little coherent in the interior, but hardening on the surface so as to resist decomposition more than the adjacent limestones, consequently the bluffs of sandstone remain abrupt and prominent, whilst the limestones are concealed. I have in no instance observed this sandstone indurated, as if by metamorphic action, so as to resemble a quartz rock. This is said, however, to occur at the knob north of Ridgeway, already noticed, but I have not had an opportunity of verifying it. Such induration I have repeatedly observed in the lower sandstone. This rock is usually thick bedded, but sometimes in thinner layers, and even schistose, particularly along the branches of the Pecatonica and Sugar river. It never presents calciferous beds like those so common in the lower sandstone. This is probably owing to its occurrence as a comparatively thin bed, between very thick masses of limestone, while the lower sandstone is a formation of very great thickness, in which calciferous beds, sometimes forming well marked limestones, are deposited, as the upper sandstone is deposited among the limestones.

The upper sandstone follows closely in its distribution the overlying blue limestone. In the mineral district it forms lines of bluffs along the outskirts of the terraces of blue limestone, or appears merely as a bed in the abrupt sides of valleys and ravines. Bluffs of this sandstone extend all along the northern frontier of the mineral district, towards the Wisconsin, extending far into the valleys and ravines, and to a considerable extent, though less uniformly, along its eastern frontier towards Sugar river. In the interior of the district, this sandstone is exposed along the valleys of streams in the same manner as the blue limestone, but to a less extent, and in some instances at the centres of elevation, presents low detached ridges quite isolated. On the Mississippi it rises above the water level south of Platte river, but apparently sinks again below it above Potosi, not being exposed at Cassville, nor on Grant river at Waterloo. It again rises north of Cassville, but along that part of the Mississippi is apparently of little thickness. It appears on Grant river south of Beetown, and extends to the upper part of that river and its branches, and in particular is largely exposed near the break at the head of Pine Fork already noticed. I extends along the Big Platte far towards its source, and from the extraordinary elevation on that stream at Ellenborough is sometimes largely exposed. This is observed at the ferry east of Potosi where it forms by itself a low ridge in the valley, underlaid by the lower magnesian, and also north of Whittaker's diggings, where it presents bluffs, one of them abrupt and isolated. On the Little Platte, in the middle part of its course, it is not exposed, but it again appears, in the upper part of its course, at the apparent centre of elevation north-west of the Platte Mounds. On Fever river it occurs only for a short distance, at the point of elevation, at Meeker's Grove, and on the east side forms there a low terrace of some extent uncovered by the blue limestone. On the West Pecatonica it is largely exposed at the centre of elevation, near Mineral Point, particularly on the east fork west of that village. It extends from that centre towards the sources of the different branches of that river, but less far than the blue limestone, and towards the south only in the vicinity of Bonner's branch, while the blue limestone is apparently exposed along the whole course of the river to the centre of elevation south of Wiota.—The upper sandstone is there again exposed, forming low detached swells in the valley. On the East Pecatonica it is exposed in a similar manner at Argyle, and from this centre, bluffs of this rock may be traced along the main stream and its branches far towards their sources, in some places apparently higher and more detached than others, marking points of greater elevation. This occurs on the Dodgeville branch, south-east of Dodgeville, where the rock makes a large dip to the south. At the centre of elevation, on Skinner's branch, this rock forms several detached ridges and bluffs, and is to a large extent uncovered.

North of the Wisconsin, between the Mississippi and the Kickapoo, the upper sandstone extends along the sides of the ridge towards the south, and overlies its summit for a short distance north of the iron mountain. Farther north, it appears only in more or less detached ridges or mounds, along the summit of the main ridge, but in a few instances along its sides, generally overlaid by the blue limestone, nearly as far north as Viroqua, but farther north uncovered. These ridges have generally an east and west direction across the divide, but in some instances these east and west ridges are connected by north and south ridges extending along the divide, so as to form a continuous series. The most southern of these ridges is Mount Sterling, entirely detached and covered with blue limestone. Towards the north the sondstone becomes more detached, and presents only small mounds and points of rock on the higher parts of the surface. The farthest north to which this rock extends, is along the north of Coon Prairie, in the north part of Bad Ax county. In two remarkable instances, the sandstone forms high detached pillars of small diameter, the remains of more extended masses. One of these, called the monument, is on the ridge road south of Bad Ax village, at the east point of a ridge of sandstone. Its diameter is least towards its base, and it appears near its fall. The other is north-west of Viroqua, near the road from Springville to Coon Prairie. These high and slender pillars here stand on a common platform, and are known as the three chimnies. They are part of a line of detached sandstone rock extending north from an east and west ridge of the sandstone. On the east side of the Kickapoo, on the road from Viroqua, by Reed's Mills, to Port Andrew, on the Wisconsin, the upper sandstone appears only as detached outliers on the tops of ridges of the lower magnesian, and that only on the south towards the latter river.

In the valley of Sugar river, beside the high detached ridges capped by the blue limestone already noticed, the upper sandstone forms by itself lower ridges and swells, and probably underlies many such where it is concealed by drift. Near the head of the valley, at Cross Plains, a remarkable detached ridge of this rock occurs in the middle of a large basin between swells occupied by the lower magnesian, in which the latter rock is higher than the base of the sandstone, offering a satisfactory instance of the undulation in the strata. East of Sugar river the upper sandstone appears an attendant of the blue limestone, either underlying that rock in bluffs, or on the sides of ridges, or forming low swells where the higher ridges are over laid by the latter. It may be traced here and there throughout the tract occupied by the blue limestone, east to Rock river, and then north to the detached ridge west of Waukau, already noticed. Along the west border of this tract, where it extends towards the north, I have observed no outliers beyond the limits of the blue limestone, except along the east side of Sun Prairie, north of Madison, where it caps low ridges occupied by the lower magnesian. In general, throughout this whole extent, from Sugar river, the sandstone presents its usual character even to the most northerly locality near Waukau. It is everywhere the same white, fine grained, friable quartzose sandstone, more or less liable to stain red or yellow, and the peculiar characters noticed near its junction with the blue limestone are often observed. In once instance, in the west bank of Koshkonong creek, at the village of Clinton, I observed a peculiarity in this rock which I have no where else noticed. A bed of thicker, hard, grey jointed sandstone was there traversed in its middle by a band of thin, white, marly sandstone, itself traversed in the same manner by nodules and layers of white flint. The sandstone here rises high on the side of the ridge east of the creek, and this peculiar bed must be towards the lower part of the rock. The occurrence of flint in a calcareous bed in the sandstone, illustrates the segregatios process by which flints were formed in the limestone.

## THE LOWER MAGNESIAN LIMESTONE.

This formation I had not examined through its entire depth previous to my former report, but had then observed in it two distinct beds analogous to the upper and middle beds of the higher limestones, and suggested a third l wer bed, which my obsertions this season have verified. I noticed as distinctive characters of this formation a peculiar concretionary nodular structure, and the occurrence of geodes lined with minute crystals of quartz, and of layers of flint less interrupted and nodular than in the preceding limestones, either abounding in geodes of quartz or resembling a striped jasper and then rarely geodic. The nodular structure is exhibited particularly in the weathered surface, and most in the middle bed. The layers of flint are chiefly observed in the middle bed, where they sometimes occur nearly massive, forming small subordinate beds. A thick bed of this kind occurs near the upper surface of the middle bed accompanied with thin layers and seams of green marl, and the position in which most of the mineral found in the lower magnesian, has been discovered. Layers of a thin laminated flinty quartz are found in this subordinate bed along with the varieties of flint above noticed. The flint where the mineral is found is much stained with iron or accompanied with iron pyrites, thus presenting the characters of an opening. Besides the geodes lined with minute crystals of quartz, which are found chiefly in the flint, and when in the limestone are inclosed in a very thin coat of flint, other small geodes are observed in the limestone, particularly in the lower bed lined with small but less minute crystals of white quartz. These last I have observed in the beds of limestone occurring in the lower sandstone, but the flint of the lower magnesian appears to be peculiar to that rock. The upper and lower beds much resemble each other, and are composed of a more even compact limestone than the middle bed, but in which the nodular structure above noticed may be observed. Alternations of marly and subsilicious layers occur in these beds but chiefly near their junction with the adjacent sandstones. In that position too, oolitic layers are generally observed. The middle bed is composed of a harder and purer limestone, of a more distinctly nodular structure, and abounds in flints like the middle bed of the upper magnesian. The lower magnesian is nearly or quite destitute of fossils, nor have I yet observed any wherever I have examined it. Caves are found in it apparently more frequently than in the other limestones, and there generally abound in stalactites, the whole cavity being often lined with them. A remarkable cave of this kind occurs on the Little Kickapoo near the discoveries of mineral noticed in the former part of this report. Sink holes are very common on the surface of this rock, caused apparently by subjacent caves. They are found too on the surface of the upper magnesian, and even of the blue limestone in the mineral district, sometimes equally remarkable, but are there less frequent. In one instance near Lodi, (Columbia county) on the south-west, I observed a vertical crevice in the lower magnesi n chiefly occupied by a massive fibrous carbonate of lime accompanied with ochre resembling a mineral vein, but no ore was apparent. This substance might be used for ornamental purposes, but is in too small quantities for other use. The Richland marble is apparently situated in the present formation, but I have not yet been able to visit it. The lower magnesian is quarried for building, particularly in its lower bed, and in some instances is burnt for lime, and although this is inferior in whiteness and slow in slacking, yet it forms a strong mortar.

South of the Wisconsin, the lower magnesian is little exposed, except in the vicinity of that river. It first appears on the Mississippi, at Ray's Landing, and rises as it proceeds northward, forming a lower terrace of bluffs to the Wisconsin, where the greater part of its thickness is exposed. Along the south side of the latter river, it forms a line of bluffs along the main valley, and extends in the same manner into the valleys of the different branches, and even into the ravines nearly to the divide at the military road, forming narrow terraces or slopes, where the upper part of the rock is concealed. In ascending the Wisconsin, the lower sandstone emerges, and the lower magnesian rises gradually higher in the bluffs. In the interior of the mineral district, this rock is exposed more or less at the centres of elevation already noticed. On Grant river it appears east of Beetown, and rises in low bluffs at Barber's Mills, above the junction of Pine Fork. On the Platte, it emerges near the ferry east of Potosi, and at Ellenborough, rises on the west side of the Big Platte, to at least a hundred feet, occupying a point in a bend of the river. Near Mineral Point, it appears in a low bluff along the east fork of the west Pecatonica, above the junction of Pedlar's Creek, and may be seen just emerging at other points in that vicinity. South of Wiota, it rises a few feet in the east bank of the west Pecatonica, at J. McKnight's, on the road to Winslow. At the other centres of elevation, I have not observed it. It appears at a few detached points in the valley of Sugar river, and would probably be there largely exposed if it were not concealed by drift. In my forme report I have noticed its occurrence at a few feet beneath the surface in the plain east of that river, and at a small elevation on its west fork at Primrose. It occupies several low swells in a basin at Cross Plains, near the head of that river, already noticed, and has lately been exposed by excavation in a similar swell on the south of Dayton village. The valley of Sugar river offers an extensive denudation of the upper strata, through a large part of its extent, probably to the lower magnesian.

North of the Wisconsin, it forms a low terrace, in the valley of that river, near its junction with the Mississippi. It extends along the sides of the main ridge between the Mississippi and the Kickapoo, forming a line of high bluffs, east of Prairie du Chien, where it reaches to the level of the plain, and is overlaid by the upper sandstone and blue limestone. Farther north the lower sandstone emerges, and the lower magnesian rises higher in the bluffs, while the overlying formations recede more and more towards the summit of the main ridge. South of Mount Sterling the lower magnesian extends across that ridge, and farther north occupies the surface except at the detached ridges and mounds of sandstone, already noticed, as far as the south side of the valley of the La Crosse river. Towards the north, as we approach the Mississippi, and the Kickapoo, it is more and more invaded by the lower sandstone, which gradually rises to the tops of the bluffs, leaving only a thin cap of the lower magnesian at the summit. On the south of the La Crosse it apparently terminates at some distance from the main valley. In descending the Little La Crosse it appeared to run out on the tops of the bluffs, at least five or six miles south of the Leon, near the south side of that valley. In ascending from the town of La Crosse by the State Cooley, the bluff at the head of the latter, at least three miles from the Mississippi, were composed entirely of lower sandstone. The northern frontier of the lower magnesian then apparently extends along the south side of the La Crosse valley, and may be continued west along the south side of the valley of Root river (Minnesota). These two valleys lie in nearly the same east and west line, and form a remarkable break across the country in that direction. Outliers of the lower magnesian may be found beyond that line, but the beds of limestone which I have observed farther north has appeared to me subordinate to the lower sandstone. I have not yet had an opportunity of tracing the frontier of the lower magnesian from the Little La Crosse to the east side of the Wisconsin, opposite Sauk City, but it must pass west of the Little Baraboo and south of Sauk Prairie, where the lower sandstone occupies the surface, only a few outliers of the lower magnesian being found near the former. This latter rock at least occupies the surface in the south western part of Richland county on the road from Reed's Mills to Port Andrew, overlaid only by a few outliers of the upper sandstone.

I have already stated the manner in which the lower magnesian extends along the south side of the Wisconsin. Its southern border there apparently extends east south-easterly from some point north of the head of Sugar river, by the south side of the prairie at Middleton, to the east point of a ridge south of Dead Lake, near Madison. It appears again north of Madison, near the east side of Sun Prairie, where it is overlaid by the upper sandstone. Between these two points the lower sandstone is exposed adjoining the Fourth Lake, particularly on the south, at the quarries west of Madison, in one of which at least it is distinctly overlaid by the lower magnesian. From this exposure of the lower sandstone and on the east side of Sun Prairie, north of it, the lower magnesian apparently extends across the country to the east side of the Wisconsin, opposite Sauk City, above noticed; and may be traced thence north north-easterly, within corresponding limits, at least to the east side of Wolf river, at Hortona. Its western frontier or outcrop, may be most easily traced, as it generally presents an escarpment in that direction, towards a lower surface, occupied by the lower sandstone. I have crossed this frontier on the east of Lodi village, about half way between Otsego and Wyocena, two or three miles east of Marcellon, and about the same distance north-west of Kingston. It then passes by Princeton, on Fox river, north of which I have observed it between Berlin and Waukau, at Eureka, on the east side of Fox river, south of Omro, and at different points in a ridge along the east side of Lake Poyagan, north of Winnekonna. Specimens of this rock were shown me at Appleton, from extensive ledges at Hortona, east of Wolf river, farther north. South of the head of Fox river, the country traversed by the lower magnesian, is mostly occupied by prairies, which form a connected series, from Middleton on the south, to Portage prairie, in Scott and Randolph on the north. I have observed this rock at different points on the latter prairie, and in Randolph, towards the east, lead has been found in it in sinking for wells, in two instances, in the same connection with flint and green marl, as on the northern border of the mineral district near the Wisconsin. The series of prairie is continued north east in the Green Lake and Ripon prairies, but these are rather in the range of the blue limestone, though large accumulations of limestone fragments are found upon their surface, apparently derived from the lower magnesian.

Outliers of this rock may occur at different points west of this frontier in the country occupied by the lower sandstone, but the only one I have visited is at Eagle Hill (Westfield,) in the northwest corner of Marquette county. The rock at this locality, though so remote from the main body of the lower magnesian, has the distinctive characters of that rock, its concretionary structure, and its peculiar geodic flints. It occurs there in two contiguous bluffs in which the rock has a large dip, on the whole, to the north, but on the west side more to the east, as if to a centre, and at one point on the south side of the west bluff, the lower sandstone is exposed, exhibiting characters peculiar to the point of junction. The rock is quarried for lime by Mr. R. M. Brown, and like the lower magnesian, generally gives a brown lime, slacking slowly, forming a strong mortar. Its remote position in a part of the country destitute of limestone, gives it a peculiar value.

The frontier of the lower magnesian, above indicated, sweeping around from the Mississippi, first east by the south side of the La Crosse valley, and then south-east to the Wisconsin near its bend to the west, and then bearing N. N. E. to the east side of Wolf river, is, if I mistake not, the limit towards the north of all the great limestone formations in the State; all the country beyond it, as far as I have proceeded being occupied by the lower sandstone, except in a few instances, where the primary rocks are exposed. The great curve to the south, at the bend of the Wisconsin, is connected with the exposure of the lower sandstone, near Madison, and with the remarkable denudation of the upper strata in the valleys of Sugar and Rock rivers, extending south into Illinois. These taken together would seem to indicate an extraordinary upheaval in that direction, which may be rendered more probable when certain facts pertaining to the arrangement of the lower sandstone, and of the primary and metamorphic rocks connected with it have been stated.

### THE LOWER SANDSTONE.

This formation is apparently of very great thickness, and occupies a wide extent of country north and west of the frontier of the lower magnesian. It is far less uniform in its character than the upper sandstone, and includes a number of different beds, varying in composition from a pure silicious sandstone to a well marked limestone. It might indeed be regarded as a group of different formation, but to determine the precise position and extent of these would require a more detailed examination, rather than such a hasty reconnoissance as I have been able to make. In that part of the country east of the Wisconsin occupied by this formation the rock is very rarely observed, and appears to have been subjected to great denudation and concealed by drift. Farther west, towards the Mississippi, it has suffered less denudation and is much more exposed, but the denudation increases towards the north until as we approach the pineries only a few ridges and mounds remain, the greater part of the surface being there covered with drift. Beds of pure white silicious sandstone are found at different levels in this formation, sometimes quite thin, at other times of great thickness, but the greater part of the rock is less pure and apparently contains a portion of lime even where not obviously calciferous, in consequence of which the rock is generally less incoherent than the upper sandstone, and so better adapted for building. The pure silicious beds are generally as friable as the upper sandstone. The presence of lime in this rock may account for the fertility of the sandy soils in that part of the country occupied by it, which will appear remarkable to one accustomed to similar soils in other districts. The lime disseminated through this rock is often found in grains and concretions, the latter sometimes of a tabular from and traversing the layers vertically. Iron is also very generally disseminated through this rock, and the greater part of it is thus stained yellow or brown, and in many instances, parts of it are so iron shot as to be hard and heavy like iron ore. These iron shot portions usually occur as seams, and sometimes as tubes traversing the rock in different directions, and occasionally as layers or even as beds interstratified. A bed of this kind, of considerable thickness, and which might even be regarded as an iron ore, was observed by me near the dells of the Wisconsin river. The iron thus disseminated was probably originally in the state of iron pyrites, which sometimes is now observed unaltered. This rock, although sometimes as thick-bedded as the upper sandstone, particularly in the more purely silicious portions, is generally in thinner layers, and sometimes even thinly schistose.

The most remarkable feature in this formation is the occurrence of distinct calciferous beds, some of which may be regarded as truly limestones, and are burnt for lime, while others may be considered as marl or marly sandstone. Some of these are quite thin, while others are of great thickness, and might be regarded as subordinate formations. The oolitic structure is common to the calciferous beds in this formation, and is found largely pervading them, particularly the purer limestones, while in the higher limestone formations I have observed it only at their junction with the sandstones. This has appeared to me important in determining whether such beds in the tract generally occupied by this formation are subordinate to it, or continued from the overlying limestones towards the south. In these positions, where the lower sandstone is found overlaid by the lower magnesian, a calciferous bed, usually of considerable thickness, is generally found but little below the line of junction, but sometimes overlaid by a thin bed of pure white sandstone. At the base of the lower magnesian there are generally a number of marly and sandy layers, often oolitic, which mark its junction with the sandstone. The calciferous bed below varies from a marly sandstone through a thin soft marl to a thicker, nearly compact marly limestone. It is often stained green by iron, particularly near its surface and at the seams, particularly the thinner, more marly portion. Such beds I have observed well marked at Reed's Mills, in the bluff, on the west side of the Kickapoo, and in the ridge north of the village of Lodi. The sandstone quarried near Madison is a marly sandstone, in the same position, near its junction with the lower magnesian. I had not observed the latter rock overlying it previous to my last report, but in one of the quarries north of the railroad, I have this season found that rock distinctly overlying. The rock in this bed has always a peculiar yellowish tint, which may be considered characteristic. A similar calciferous bed is generally observed near the tops of the higher bluffs in the country east of the St. Croix, particularly in those near the Falls of the Kinnickinnic. These bluffs are from one to two hundred feet in height, and present distinctly the characters of the lower sandstone in the alternations of subcalcarious, and sometimes even thin limestone beds with the purer sandstone. It is beneath these high bluffs that a very extensive and thick bed of limestone is situated, occurring at different points along the east side of the St. Croix, from Prescott northward, which has been considered in Owen's Reports, as a continuation of the lower magnesian. The The consideration of this bed is important in dertermining whether the limestones of the upper Mississippi, which have been regarded as the same formation as the lower magnesian before discribed, are really so, or only subordinate to the lower sandstone. This bed extending along the Mississippi, above and below the St. Croix, and along the latter to within five or six miles of Hudson, evidently passes under the high sandstone bluffs above noticed, as it may be traced at the level of their base to within a short distance of them. The same bed obviously forms the Falls of the

Kinnickinnic, where it still more evidently underlies the numerous high sandstone bluffs in that vicinity.

It appears again at the falls of Willow river where it is deeply intersected and shows a great thickness as well as in the vicinity of Prescott. A bed of a similar limestone was observed by me, at a comparatively low level in the great woods west of the Menomonee, near the creek entering that river below Wilson's mills. This rock has appeared to me very different in its character from the lower magnesian. It generally shows more or less of the oolitic structure, like the smaller limestone beds which occur in the lower sandstone, where it is distinctly marked by its position relative to the lower magnesian. I have never observed in it the peculiar flint of the lower magnesian although geodes of quartz are not unfrequent. The sandstone which overlies it is of much greater thickness than the upper sandstone, and corresponds in character with the lower sandstone, particularly in the presence of lime either disseminated or in calciferous beds, resembling those occurring in that formation where it is unquestioned. Such a bed occurs at Winslow's quarries, on a ridge, two miles southeast of Hudson, at a much higher level than the great bed just noticed, and evidently subordinate to the sandstone; partly composed of a calciferous sandstone, and partly of a nearly compact limestone burnt for lime. Beds of this character of little thickness have been observed in the lower sandstone near its southern border, where it approaches the frontier of the lower magnesian, but at a lower level in the formation than the calciferous bed near its upper surface. Such a bed extends along a ridge on the west side of Sauk Prairie, near Otter creek, and another occurs near the Baraboo narrows, apparently of limited extent, and near the base of a high bluff of sandstone. The latter has been quarried for lime, but the lime from this as well as from the bed near Hudson, although it gives a strong mortar and might answer for cement, is more difficult to slack than that from the lower magnesian.

The considerations here offered have induced me to regard the great bed apparently extending from Prescott to Willow river, as subordinate to and at a considerable depth in the lower sandstone. A bed of a similar character, but of much less thickness, extends along the top of the bluffs at Stillwater, west of the St. Croix.—This bed is underlaid by sandstone, apparently the same as that in the bluffs overlying the former. Calciferous beds, but more of the character of calciferous sandstone, occur on Apple river, at McCarty's Prairie (Polk county) and at the Falls of the St. Croix. At the latter the sandstone is arranged in its usual nearly horizontal position, on the side of an abrupt ledge of the trap or greenstone forming the falls, and includes beds of a thin marly shale. The rock is more or less fossiliferous, and the shale nearly composed of shells. The *Lingula* is the most abundant and characteristic. I have noticed it at different localities in the lower sandstone, as far as Sauk Prairie, but always in calciferous beds or layers. I have in no instance observed fossils in the purer silicious sandstone. On the summit of a bluff, one or two miles west of the St. Croix, opposite Hudson, I observed in a quarry a bed of limestone abounding in shells, particularly *Leptænæ*, and resembling by these and other fossils, and even by its structure, the shell bed of the blue limestone, but evidently disconnected with beds resembling the other beds of that formation and immediately connected with a sandstone at the same level with that in the high bluff east of the St. Croix, which I have regarded as the lower sandstone. I was shown at Prescott a specimen of a *Leptæna*, from one of the high bluffs north-east of that place, indicating the presence of the same bed in that position. This shell bed has appeared to me also subordinate to the lower sandstone, but at a higher level than the beds before noticed. In proceeding through Minnesota from Prescott, by Hastings, to La Crosse, I observed beds of limestone in bluffs and ravines throughout a great extent, generally at a higher level than the great bed east of the St. Croix.

The general character of the rock was similar to that of the latter, and in no instance presented the peculiar characters of the lower magnesian. Where I had an opportunity of observing it distinctly exposed, it appeared to form a bed included in the sandstone. It appeared so in the bluff along the west side of Cannon river, and in different bluffs along the west side of the Mississippi and Lake Pepin, from Redwing to near the Zumbro river. On the prairies, it appeared only in points and ravines disconnected with other rock, but in a recent excavation on the government road, west of Lake Pepin, in ascending to the high prairie, it was distinctly overlaid by sandstone. In crossing the prairie, south of the Zumbro, the rocks appeared in the same disconnected manner as on the prairies farther north, but south of the Whitewater, it evidently passed under a range of sandstone bluffs, crossing the prairie from east to west. In crossing this range, I observed an overlying bed of fossiliferous limestone, perhaps analagous in position to that west of Hudson, but not marked like that by *Lepœtnœ*, and immediately with a sandstone, having the characters of the lower rather than the upper sandstone, which continued to show itself near the surface, at a level corresponding to that in the bluffs south of La Crosse, passing under the lower magnesian. I have only given here a very general statement, sufficient to convey the impression made on me by the facts observed. I have thought it proper to state that impression in the hope that it may attract the attention of others who may have opportunity for a more detailed examination. It has appeared to me not improbable that those are different beds of limestone in the lower sandstone, some like the lower magnesian, containing few or no fossils, like the great bed east of the St. Croix, and the limestone extending on the west side of the Mississippi, south of the Whitewater, and others abounding in fossils like that at a low level, at the falls of the St. Croix, abounding in *Lingulœ*, and that at a higher level west of Hudson, analagous to the shell bed of the blue limestone. The lower sandstone, as we proceed east from the Mississippi, does not indeed present such remarkable beds of limestone as extend along the upper Mississippi; but calciferous beds occur there even in the vicinity of the Wisconsin. In that part of the formation the calciferous beds appear to be of limited extent. That at the Baraboo Narrows, offers an apparent instance of this, nor is the marly bed near the junction with the lower magnesian always equally developed. The lower sandstone in the country traversed by the upper Mississippi, may thus be more pervaded by beds of limestone which do not extend in an equal degree towards the east.

Layers occasionally occur in the lower sandstone, though unfrequently, containing rounded or flattened pebbles of quartz, often limped, apparently formed by attrition. These, so far as I have observed, are never large, and usually very small, and the latter particularly resemble concretions; still these, as well as the smaller grains of which the sandstone is composed, appear to have been rather the result of attrition. Such layers are usually thin, nor have I observed any thick beds of conglomerite in this formation.

The lower sandstone is more generally arranged in even horizontal layers, but in many instances I have observed an arrangement which I have not noticed in the other secondary formations. Layers or beds occur marked by oblique lines of stratification, and these in different directions, alternating with others in which the lines of stratification are regularly horizontal. This arrangement is strikingly exhibited at the Dells of the Wisconsin river, but may be observed in many other localities. In one instance, on the Chippewa, near O'Neil's creek, this arrangement appears to be undulatory, as if formed by the action of waves, but in most instances the oblique lines appear to extend only across the layer or bed. Such oblique lines, alternating with horizontal, I have observed in beds of drift sand.

Rocks apparently of metamorphic origin are observed in connexion with the lower sandstone. That most evidently connect-

ed with the sandstone is a white or slightly bluish compact quartz, resembling a primary quartz, either forming beds or layers in the white friable sandstone, or traversing the same vertically, in the manner of a dike. A very thick bed of such a quartz rock occupies the summit of a high bluff, west of the Trempeleau, by the stage road from Black River Falls to Hudson. This rock overlies the sandstone in regular strata, with thin layers of friable sandstone interposed, and even includes nests of the same in its mass. I have observed the same quartz in other instances, forming only thin layers, or limited deposites or nests interposed in the sandstone. A remarkable instance of an apparent dike of the same quartz rock occurs in the Musquito mountain, in the town of Almond, (Portage county,) two or three miles west of the Portage and Stevens Point road. This rock here extends in the manner of a vertical dike along the middle of a long narrow ridge, bearing nearly east and west, and is bounded on each side by lower terraces of friable sandstone, and is more or less blended with the latter, like the quartz bed on the Trempeleau. This dike would seem to have been formed along the line of a fissure
by the action of some nt then escaping, capable of changing
the sandstone into artz. Mounds of a granular
quartz rock, includi ur near Black River
Falls, apparently e ne, and pre-
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Rush rivers, across the point between the Menomonse and the Chippewa, and by the heads of the Buffalo river and the Trempeleau, to Black River Falls, and thence north of the Lemonweir to the Wisconsin and Fox rivers. This rock is mostly concealed by sand or drift, and is exposed only in more or less detached ridges, or mounds, or in low swells or plateaus. Some of these ridges or mounds are singularly detached, such as the Roche a Cris, the Mosquito mountain and Pilot Knob, east of the Wisconsin. I have visited only the two last of these, and have there observed appearances which may account for their preservation amidst the general denudation. The Mosquito mountain appears to have been preserved by the dike of quartz rock traversing it, above noticed. The Pilot Knob is traversed in a similar manner by a narrow dike-like mass of rock, intersected throughout with seams of hermatite, and rising to a great height, bordered by lower swells of friable sandstone. This subject will be farther considered when I come to treat of the conformation of the surface.

Within the frontier of the lower magnesian, the lower sandstone is exposed only to a small extent, generally underlying the former in the bluffs along the rivers and smaller streams. It is not exposed on the Wisconsin at its junction with the Mississippi, but gradually rises in ascending that river, till it occupies more than half the height of the bluff at Clifton, opposite Sauk City.—It does not appear in the bluffs east of the Mississippi, till some distance north of Prairie du Chien, but rises to the tops of the bluffs south of La Crosse. It nearly reaches the tops of the bluffs adjoining the Kickapoo, at Reed's mills, and extends far back into the ravines. East from that stream it is more and more exposed till it occupies the tops of the ridges adjoining Sauk Prairie. The most remarkable exposure of the lower sandstone within the frontier of the lower magnesian, is that on the Fourth Lake, near Madison. The country from the Wisconsin to that point is apparently overlaid by the lower magnesian, but that rock is there denuded to a limited extent, particularly along the south side of the

Fourth Lake, and the lower sandstone exposed. This rock is quarried there near its junction with the lower magnesian, and is more or less calciferous, which renders it sufficiently coherent, and this with its fine grain, and other qualities as a freestone, will give it great value for building. The exposure of this rock seems to make a centre of elevation at that point, apparently connected with the basins of the lakes, and with the great denudation of the upper strata, extending through the middle of the strata, from north to south.

### THE QUARTZ ROCK,

### (*Of the Baraboo, and of Portland.*)

The quartz rock in the ridges adjoining the Baraboo valley, on the north and south, and that east of Portland, are so similar in character, that they may be considered in connexion. The rock, in both instances, is a light or dark grey hard granular quartz, marked more or less distinctly by parallel lines of stratification, and resembling much a primary granular quartz, but presenting certain peculiarities both in position and character, which seem to indicate it an altered sandstone. This rock, adjoining the Baraboo valley, lies within the limits of the lower sandstone and forms either detached ridges, in the range of ridges of the sandstone, or is more immediately connected in the same ridge with the latter. East of Portland, it appears in two parallel ranges, apparently detached from other rocks on the east side of a marsh traversed by Waterloo creek, on the west side of which the upper sandstone occurs overlaid by the blue limestone. In the Baraboo rock two characters are not unfrequently observed which appear to connect it immediately with the lower sandstone. These are the occurrence of layers more or less filled with rounded pebbles of quartz, usually very small but sometimes larger, precisely resembling the layers of the same kind in the lower sandstone, and also of obliquely cross lines arranged between the regular lines of stratification in the manner already noticed in the latter. These appearances I have not observed in the Portland rock nor in the upper sandstone, with which that rock from its position might be regarded as connected. But the rock in both instances is so similar in general character as to render a common origin probable. In the Baraboo rock, cross veins and nests of white quartz, sometimes containing geodes of very distinct crystals are found in some localities, particularly in the ridge south of Devil Lake. Titanic iron resembling the *Crichtonite*, not unfrequent in primary quartz, is also found in that rock, generally in their seams, but one instance noticed in a ridge north of the valley east of Baraboo village occupying a vertical vein two or three inches thick. In the Portland rock, in its eastern range, I noticed cross seams at the joints of a dark green mineral resembling hornblende.

The quartz rock, adjoining the Baraboo valley, forms two ranges, one on the north, the other on the south, which are apparently connected on the east by a ridge of sandstone, closing the valley in that direction, the Baraboo passing through to the Wisconsin by the narrows, a gorge at the east point of the range of quartz on the north. The ridges of quartz rock are less elevated on the north and appear generally detached from the sandstone. On the south the ridge adjoining Devil's Lake on the east and west are more than three hundred feet in height and are parts of the same east and west range, deeply cleft at that point. These ridges also appear detached from the sandstone, but farther west on the same side of the valley I noticed a ridge of this rock at the summit of a high ridge chiefly composed of the sandstone. In general the bearing of the ridges is here east and west, and the dip as determined by the lines of stratification, but moderate to the north. If this rock was formed from the sandstone by ignious action from beneath, as the circumstances already mentioned seem to indicate, this metamorphic change does not seem to have been accompained by much disturbance of the strata, although from the great height of the hills surrounding the valley, particularly on the south and east, there may have been a general upheaval as at the centres of elevation in the mineral district. The quartz rock of Portland, is largely exposed in a low ridge on the east side of the marsh at Waterloo creek, and less so on the west side of a ridge about a mile farther east. The bearing of these ranges is south by east, and the apparent dip about twenty degrees east. By a recurrence to the map, it will be seen that the bearing of the quartz rock at Portland from that at the Baraboo, is about E. S. E.

### THE PRIMARY ROCKS.

These in the part of the State which I have visited are confined to a few detached localities, some of which at least are connected in more extensive ranges. These localities are all within the limits of the lower sandstone, and most of them occur at the falls of the northern rivers. The lower sandstone appears in no instance to have resisted the action of the currents, but to have been deeply cut through, forming the Dells of those rivers. The harder primary rocks have, on the contrary, resisted that action, and whenever they have crossed the channels of the rivers, have formed falls or rapids. Generally these rocks are little elevated, but in a few instances they form ridges of considerable height. In most instances they are not observed in immediate connexion with the sandstone, but in a few instances, particularly in the banks of rivers, I have noticed the sandstone in such connexion, either overlying or on the sides of the primary ledges, but rather appearing to have been deposited subsequently to the formation of the latter than to have been disturbed by their intrusion. A few instances where the sandstone may seem to have been disturbed will be noticed incidentally. But though the sandstone would seem to have been deposited after the primary rocks had been formed, yet in several instances it has been apparently modified at its junction with the latter; either a thin band of white compact quartz such as has been already noticed in the sandstone adjoining the primary rocks, or the sandstone in that position appearing more indurated or modified in color or composition. These changes do not, however, appear to have been the result of any decided igneous action.

The primary rocks which I have examined in this State, appear to be of the same class with those of New England. They present, indeed, as already stated, the most striking analogy to the latter, both in their character and combination, and appear to have been the result of the same general causes. Whether these causes have operated in the two instances, at the same general period, or at remote intervals, can only be determined by a minute examination of the circumstances attending each, but when so great a resemblance prevails, they might be presumed to be of the same period, without decided evidence to the contrary. I have already stated that I have not yet observed any trap rocks in the localities visited by me, analogous to the proper intrusive trap, or such as intersect rocks of a very different character, such as sandstones. The rock most nearly resembling such intrusive trap, namely, that which occurs at the falls of St. Croix, and in the vicinity, has rather the character and arrangement of the primary greenstones. In the other localities visited, where trap rocks have been indicated, I have observed only hornblende and sienitic rocks clearly primary in their character and connexion. Although the primary rocks generally occur only in detached localities of limited extent, yet these are not disconnected, but are combined in a number of groups or local formations, as in districts occupied by primary rocks exclusively. In my report on the geology of Connecticut, I endeavored to distinguish the local formations in the primary rocks of that State. Similar local formations may be clearly distinguished in the primary rocks of this State, although occurring only at detached points, separated by wide intervals of drift or sandstone.

An extensive range of primary rocks may be traced through the counties of Marquette and Waushara, commencing on the south of Fox river and extending N. N. E. towards Waupacca county.

This may be called a sienitic range, although including rocks varying from a light red sienitic, in which felspar predominates, to a dark green stone in which hornblende prevails, and even to a gneiss containing both hornblende and mica. These different rocks occur in distinct subordinate ranges. On the west is a range of red sienite, which I noticed on the south on the north side of Fox river at Montello, and then N. N. E. from that point in the town of Marion, in Waushara county. This rock is a compound of red felspar and dark green hornblende, in which the former largely predominates, sometimes with a little quartz disseminated. A parallel grain can be more or less distinctly observed, but the rock is generally solid and thick-bedded, very rarely showing a tendency to cleve in the direction of the grain. Cross veins and small nests of quartz occur more frequently at Marion than at Montello. The nests appear as secretions around which the rock is more purely felspathic. At Montello, the bearing of the rock is more nearly E. N. E., at Marion, more nearly N. E. At the former place, it forms a single ridge in which three distinct beds may be distinguished; one on the north, containing more hornblende, one in the middle more purely felspathic and very compact, and one on the south resembling the latter in composition, but coarser grained and more distinctly parallel in structure. At Marion, it forms three distinct ridges, two on the west and one on the east of Spring Lake: their relative bearing transverse to that of each. Numerous boulders of this rock are scattered on the surface in the vicinity of the ledges at Marion, some of large size. This rock might be used for building, and would generally form a very indestructible material, but it is too hard to be dressed to advantage. In a line farther east is a range of dark green stone, noticed towards the south-west in the Observatory, a high ridge in the town of Buffalo, south of Montello, and towards the north-east in two groups of ledges about half way between Marquette and Grand river, on the road to Montello.

This rock is very dark colored and nearly black, but its weathered surface is lighter, and often reddish. At the Observatory it is generally thick-bedded, with a distinct parallel structure, and mostly fine grained and nearly compact, but sometimes coarser grained, when the parallel grains are more obvious. In the ledges near Marquette, the greater part of the rock is thick-bedded and fine grained like that of the Observatory, but sometimes black and smoothly compact, like a porphyry, with thin schistose layers interposed, partly even and more compact, partly uneven and more laminated. The rocks of this range might be taken at first sight for trap, but the parallel structure, and the arrangement is that of primary greenstone. This rock at the Observatory forms a high ridge, in which it is exposed at the summit and on the south, being concealed on the north by drift, and bears more E. N. E. like the rock at Montello. In the two groups near Marquette, it rises from the plain north of Grand river, in low ledges, bearing more nearly north-east, while the bearing of the groups is nearly transverse to that of the ledges. The third range extends in a line still farther east, along a ridge on the east side of Fox river, in the immediate vicinity of Berlin. The rock is there a dark grey gneiss, with a distinctly parallel structure, but thick-bedded and very slightly schistose, with interlaminated hornblende and mica, with occasional porphyritic reddish felspar. Veins of quartz intersect it both transverse and interposed. This rock by its parallel structure, and its joints, breaks readily into flat blocks, and is thus valuable for building, but is not easily dressed. The bearing is nearly north-east. The dip here, as well as in the two other ranges, is about eighty degrees west, or nearly vertical.

The two western ranges, it has been seen, apparently extend on the south-west in a more east north-easterly direction, and then bear more north-easterly. The eastern range has been noticed only at one point, east of the more northern part of the two western ranges, and has the same north-easterly bearing. These three ranges may be regarded as one connected formation, in which hornblende is the characteristic mineral on the west side, subordinate to felspar, in the middle predominant, and in the east accompanied with mica. The different parts are here remote, but in another instance, at Black River Falls, a similar arrangement will be noticed within a narrow compass.

The next point towards the west, where I have observed the primary rocks, is in the vicinity of Stevens' Point. I have visited there only three localities, viz: at the falls at Stevens' Point, and at the head of Conant's rapids, about three miles below, on the Wisconsin, and at Grier's mill, on Plover creek, E. N. E. of Stevens' Point. In the rocks of all these localities, mica is predominant and hornblende only subordinate. The prevailing rock at the two localities on the Wisconsin is gneiss, either light grey granitic, or dark micaceous in alternate beds, with veins and beds of granite, and more rarely of sienite, and a few beds of hornblende gneiss. At the falls at Stevens' Point, the rock at the foot of the falls on the east side is a hard, thick bedded dark gray, of submicaceous gneiss crossed by a large oblique vein of hard red sienite, with seams of epidote. In a ravine south-east, the rock is a rather lighter grey gneiss, with a white felspar (albite) decomposing readily to a soft clay intersected with small oblique veins of a hard red felspathic granite, and of a white felspar, decomposing to a clay, and with a few rich veins of a red sienite. It is worthy of note that the sienite at this locality contains a few scales of mica disseminated. At the head of Conant's rapids, on the east side, the rock is chiefly a light grey subgranitic gneiss, with few veins, with alternate beds of dark micaceous gneiss, more intersected by layers obliquely cross veined, and by smaller interposed veins and nests of red granite and quartz, and including thinner bands of hornblende gneiss. The south side of the ledge is much decomposed, like the rock in the ravine at Stevens' Point. This ledge is overlaid with sandstone, and at the junction there is a layer of a nearly compact white quartz, such as has been already noticed in the lower sandstone. The rock at McGrier's mill is a nearly uniform thick bedded light grey granitic gneiss, not fossile, and breaking in large blocks by jointed seams. It has the composition and appearance of a granite, but with a distinctly parallel grain, and more or less porphyritic, with a reddish felspar.

The porphyritic crystals are partly double and partly single, with minute scales of mica disseminated, both of which appearances are noticed in the porphyritic rocks of New England. This rock is generally subject to decomposition at its surface, but some of its beds are less so. It might be quarried with facility, and if it were not for the defect just mentioned, would be valuable for building. The general bearing of the primary rocks near Stevens' Point, is nearly east and west, varying from E. N.-E. to E. S. E., and the general position nearly vertical.

The next group of primary rocks towards the west visited by me is that of Black River, extending upwards from the falls. In this hornblende is the characterestic mineral, and the rocks are sienite and greenstone accompained with chlorite slate. The falls are formed by a sienite composed of red felspar and dark green hornblende, the weathered surface light red, the interior darker from the hornblende. This extends up the river about a mile where it occupies the west side opposite Lewis' iron mound and is there bounded on the east by a band of dark greenstone, partly schistose, and even or contorted and partly thick bedded, and this by a band of thin dark green chlorite slate in the east bank immediately adjoining on the west the bed of iron ore in the mound. This bed is apparently bordered on the east by the same chlorite slate but is nearly concealed on that side by drift. The chlorite slate is accompained with bands and seams of red ochre and hematite, apparently the result of decomposition. North of the mound the chlorite slate crosses to the west bank accompained with the same red ochre and hematite, and farther north disappears under the sandstone. At Hamilton's mills, eight miles north, the primary rocks are again exposed and consist mainly of a very felspathic sienite with only slight traces of hornblende, chiefly red felspathic, but with white felspathic bands. The red felspathic rock partly distinctly porphyritic. On the east side the rock is traversed by bands of a chloritic slate partly dark green and thinly fissile, partly light green and thick with disseminated pyrites. At the Angles, one or two miles above, the primary rocks are again exposed, and consist chiefly of a thick-bedded hornblendic gneiss or greenstone, darker in the interior, but weathering lighter on the surface. This rock is generally even and uniform, and with a distinctly parallel structure. It is bounded on the west by a thin dark green chlorite slate and includes a very wide interposed bed consisting of two parts intimately connected, that on the west composed of a very fine grained or compact nearly black trap like greenstone, and that on the east of a very fine grained red felspathic sienite with a band of compact red felspar resembling a porphry. This bed appears regularly interposed, and obviously an original constituant of the primary rocks. The primary rocks are exposed at different points higher up the river, but I have not extended my examinations any further.

Quartz veins and nests occur more or less in all the sienitic and other hornblendic rocks from the Falls to the Angles, and some of those at Hamilton's Mill include segregations of felspar. The general bearing of the primary rocks of Black river is north by west, the dip west nearly vertical. The iron ores of Black river might here be noticed, as they are partly connected with one of the primary rocks above described, but the consideration of them will be deferred to their place under the head of metalic ores.

On the Chippewa I visted only two localities of primary rocks, namely, at Chippewa Falls and at the Vermillion Falls or Armontager's rapids. The rock at Chippewa Falls is a granitic gneiss or stratiform granite, with a distinctly prarallel grain, bearing northeasterly with a dip west nearly vertical. This rock is generally light grey with white felspar, but in some layers darker grey and more micaceous. It is crossed more or less obliquely by small veins of red felspar granite and of quartz. Cross bands intimately connected with the main rock in structure, very hard and fine grained dark grey, breaking by joints in obliquely prismytic fragments and chiefly composed of felspar. A similar very fine grained red felspar band was noticed with a little hornblende disseminated. The weathered surface of the rock is lighter than the interior, and often stained reddish. In some parts, where quarried, black seams apparently of specular iron are observed in the interior, which near the surface are changed to red ochre. This rock breaks by joints in large regular blocks and may be quarried for ordinary uses in building, but is less easily wrought than granitic rocks of a less parallel structure. At the Vermilion Falls the ledges are composed of a very dark, nearly black schistose rock, varying from a micaceous to a hornblendic gneiss; on the south more micaceous, on the north more hornblendic. The bearing of the rock is E. N. E., the dip north, nearly vertical. In the southern ledges, the rock is in part simply micaceous, and in part micaceous with interlaminated hornblende, in the northern ledges a hornblende gneiss with more or less interlaminated mica. This rock is traversed both on the north and south by large interposed beds of coarse red or reddish white felspar granite with veins and nests of white quartz, and by small interposed seams of white and reddish felspar.

The rocks known as Trap, forming the Falls of St. Ctoix, and traversing the adjoining county, through a large extent, may be here noticed in connexion with the primary rocks to which it has much analogy in its arrangement. A parallel grain can be more or less clearly distinguished in this rock corresponding with the strike of the ledges, and generally bearing E. N. E. with a nearly vertical dip north. Small nests of quartz and red felspar, the last giving to the rock a porphyritic appearance, and segregations differing in color and texture from the rock in general may be sometimes observed in the direction of this grain, indicating a stratiform arrangement, as in the primary greenstones. This rock is distribeted over a wide extent of surface, and presents groups of ledges, arranged transversely to their direction, as has been noticed in the sienite and greenstone rocks near Fox river. It has however the general character of trap rocks, and sometimes presents an amygdaloidal structure peculiar to those rocks, and such as I have not observed in the proper primary greenstones. It may be regarded as intermediate between the latter and the trap rocks distinctly known as intrusive. This rock is generally dark green or nearly black, fine grained and very hard, but sometimes coarser grained and then more decomposible. It is generally very solid, breaking only by joints in larger blocks, but sometimes breaks in smaller jointed fragments. Although generally uniform in character it is sometimes much pitted with seams and nests of quartz and red felspar or with seams and nodules of a light yellow, like epidote, very hard and compact, sometimes giving to the rock the appearance of a breccia or conglomerate. These latter, as well as the red felspar, are more characteristic of the primary than of the proper trap rocks.

The different localities visited by me may be here briefly noticed. A remarkable range crosses McCarty's Prairie, extending nearly a mile east from the Hudson and Falls road, but narrow, generally presenting only two lines of ledges, but at its east end two other ledges project to the north. These ledges have nearly the same easterly bearing. * * * *

# REPORT.

To His Excellency Coles Bashford,

*Governor of Wisconsin:*

I herewith submit a Report upon the Geological Survey of Wisconsin, made in accordance with an act providing for the Geological Survey of the State, passed March 3d, 1857.

Since assuming the duties of my department of the Survey, I have labored diligently to promote its objects, and with such trifling exceptions as were caused by the fulfilment of duties and responsibilities previously assumed, I have devoted my whole time to the work. The entire results of the season cannot of course be given in a matured form at this early period as much of it is connected with the work of subsequent seasons, and the precise value of other portions can only be ascertained by studies which cannot be carried on in the field.

I shall therefore attempt only a report of progress and append such matter as I have thought important to be published, from its bearings upon the undeveloped resources of the State.

In undertaking a work, which according to my contract with the State, was to continue during a series of years, it seemed proper first, to ascertain precisely what had already been done in perfecting our Geology. I therefore devoted some little time to collecting whatever materials might be in existence which would be of value in this effort. These materials were scattered through the Reports of the U. S. Geologist, in unpublished notes of lines to Railroad surveys, and in the annual Reports of other State Geologists, for the years 1854–'55 and '56.

I had also considerable material of my own gathered from time to time incidentally in my travels over the state. These scattered materials I endeavored to arrange and compile so as to indicate the stage of advancement already attained towards understanding the Geology of Wisconsin.

Thus what had been done, and what still remained to do, could be seen at a glance, and a chart was furnished from which valuable hints could constantly be drawn by the explorer.

Such a review of the ground was a pre-requisite to the economical conduct of the survey as it would save the repetition of studies already faithfully performed and point out at once the unexplored fields of investigation which remained.

In prosecuting my work, as well as in its organization, I have endeavored to keep in view the circumstances under which this survey has been initiated.

It is in a new state whose population is sparse, whose territory is of vast extent and much of it in a state of nature and whose resources are yet to be found out and developed. The condition of its treasury admits of no large expenditure for objects which are not of immediate necessity or followed by a prompt return in kind. It would be obviously impossible under any appropriation that the State could afford to make to visit every section of land within its limits, examine minutely its soil, its rocks, and every circumstance which might be of interest to the geolgist. Such a survey could only be wisely undertaken by a rich and densely populated country.

We have an example of this kind in the very thorough and minute geological survey of Great Britain, which is still in progress, and is a splendid model of its kind, both in the perfection of its organization and the masterly ability with which it is being prosecuted.

Yet it would be absurd for us to attempt an imitation of *that* noble survey in detail. Our entire appropriation would scarcely sustain the work over a single township, and the present generation would pass away, while half the state still remained unexplored.

In a new and unsettled state, with an extensive territory, a widely different policy must govern.

The geologist should aim: 1st. To grasp and present clearly the great geological features of his district, and the prominent physical resources which it contains.

2d. To study minutely those points only which promise the richest economical and scientific results, and to study these as a general rule in the order of their relative importance, so far as this can be known by a cursory survey.

3d. To present the knowledge thus obtained in such form as to be intelligible to every citizen of the state or to those abroad who may be interested in its geology, or the developement of its resources.

While this plan of action may be less satisfactory to the Geologist and less favorable to his reputation than researches prosecuted more regularly and minutely, it seems to me the only one at all compatible with the idea of bringing rapidly into notice the resources of a new State, and furnishing to its inhabitants, who are now living, a general chart of its geology.

My work during the past season has been prosecuted in the light of the ideas just expressed, and has been mainly of a general nature. I have made a series of accurately measured sections across the State in such directions as seemed to exhibit most clearly its general Geology.

Sec. No. 1. Extends from Racine along the line of the Racine & Miss. R. R. to Rock River, at Beloit, thence westward along the line of the Southern Wisconsin R. R. to the Mississippi River, opposite Dubuque.

Sec. No. 2. From Milwaukee west along the line of the Mil. & Miss. R. R. to Rock River, at Janesville.

Sec. No. 3. From Milwaukee along the line of the Watertown R. R., through Madison and the Blue Mds., to the Miss. river.

Sec. No. 4, From Madison down the Black Earth and Wis. River vallies to the Miss. River.

Sec. No. 5. From Milwaukee northwest along the line of the La Crosse R. R. to Portage City, thence westward to La Crosse.

Sec. No. 6. From Sheboygan west, through Fond du Lac, Ripon and Green Lake to Princeton, Marquette Co., on the Fox River.

Sec. No. 7. From Manitowoc westward to the Fox River at Appleton, thence to Wolf River at New London, and thence to the Wisconsin River, at Stevens Point.

Sec. No. 8. From Beloit through Madison to Portage City.

Sec. No. 9. From Beloit north through Watertown, Fond du Lac, Oshkosh, Appleton and Lake Shawano, along the line of the Chicago, St. Paul, Fond du Lac and Lake Superior R. R., to the State line north.

Sec. No. 10. From Kewaunee on Lake Michigan, westward to Green Bay City, thence to Lake Shawano and Wolf River.

These sections generally run across the dip of the strata and exhibit the outcrops and relations of the various rocks exposed along the lines which they traverse. They are generally made on lines of surveyed Railroads, or along the valleys of the principal streams, as it was only by following these that we could get any reliable standard of reference for heights and distances. These standards are of great value with us as we have no topographical survey in conjunction with our geological survey, and when reliefs are so uniform as ours, very little can be done with the barometer without bestowing more attention upon it than we could well afford.

As soon as these sections can be properly executed on paper they will be safely deposited and kept, so that in case of accident they will not be lost to the State. The failure of some Geologists to put their work into such shape as to be understood by others, has been a cause of great loss where death or other circumstances have terminated their connection with a survey.

In addition to these sections I have examined the district between the Wolf and Fox rivers and along the shores of Green Bay as far as the Oconto, also the country lying between the Wisconsin river and the Mississippi as far North as Black River Falls.

In order to forward as rapidly as possible the ecomical results of the survey, I have made special visits to such points as seemed likely to yield anything of value. These general explorations have determined many points of interest.

I have collected and forwarded to Madison over 2,000 specimens of ores, rocks, fossils, etc., during the season. For their temporary accommodation I have fitted up a room in one of the buildings of the State University where the specimens may be stored, examined and classified preparatory to being permanently arranged in the State collection. These specimens will be a valuable addition to the cabinet, and can be seen by yourself or the Legislature at the University.

The great importance of the Iron interest of our State has induced me to make it an object of special attention. Accordingly I have examined with great care every locality which promised any considerable yield of valuable iron ore, and in a few cases where important interests were involved in the quality of the ore I have submitted specimens to the distinguished chemist Dr. Charles Jackson, of Boston, for analysis. The results and all questions connected with the manufacture of iron in our State I have considered in a paper herewith appended, "On the Iron Ores of Wisconsin," to which I beg leave to call your attention.

In concluding this notice of my season's labor, it is proper to state that I have had no permanent assistant, the condition of the fund not allowing me to employ one, I have however employed such help as I could not do without at my own expense.

I wish here also to express my thanks to the citizens of those portions of the State where my work has led me for many acts of couttesy and co-operation. I am under great obligations also to S. F. Johnson, Chief Engineer, Chicago, F. & St. P. R. R.; Robt. L. Harris, Esq., of the Racine and M. R. R.; E. W. Woodward, Esq., of the LaCrosse R. R.; Jasper Vliet, Esq., of the Berlin & Horicon R. R., for the use of profiles and much valuable information and facilities for carrying forward the survey along their respective roads.

Respectfully submitted,
EDWARD DANIELS.

# Iron Ores of Wisconsin.

No metallic ores are so abundantly distributed as those of iron. They enter more or less largely into all the great mineral masses of our globe, so that it would be scarcely possible to find a fragment of rock or a handful of soil entirely destitute of iron in some one of its varied forms. In our own State these ores are unusually abundant. They occur in connection with rocks of various geological age from the primary slates to the lower members of the upper silurian formation. They are found generally in one of the following modes of occurrence:

1st. In place as beds or veins in the rocks where they were originally formed or introduced.

2d. Deposited from aqueous solutions in low ground, as bog ore or ochre.

3d. Scattered over the surface or mingled with the soil and superficial deposits in fragments or minute particles.

The valuable deposits of ore belong mainly to the first and second class. Instances of the last are however much more common, and though worthless, often excite large expectations. They are especially abundant in the sandy regions of the State, where fragments of ore are found on every hillside, and the soil is everywhere stained with iron. The coloring matter of the sandstone itself is generally derived from ores of this metal disseminated through it, whose decomposition originates the chalybeate springs which so frequently rise in the valleys along its outcrop.

Fragments of magnetic, specular and micaceous iron ore are very abundant in the drift of the central part of the State, also patches of sand, generally on the lake shore, containing minute grains of magnetic ore. These are found in connection with boulders of igneous rocks and fragments of native copper and have undoubtedly a common origin.

We have the most conclusive evidence that they were derived from the north, some of them as far even as Lake Superior, where we know similar ores and rocks exist, in place. To explain their transportation to the distant localities where we find them so abundantly, we have only to refer to the action of causes now producing similar results. On the ocean, ice-bergs are often seen by navigators floating southward far into the Temperate Zone, borne along by submarine currents, and carrying with them rocks, gravel and other materials derived from the colder regions where they were formed. As they gradually melt under the warmth of milder latitudes, their lading is slowly distributed along the path of the great current which moves them on, and thus the bed of the ocean is being strewed with the ruins of northern lands.

At a period of high absolute antiquity, but comparatively recent in the geoloeical chronology, the greater portion of our State was covered by the sea.

Far to the northward were elevated lands around which ice-bergs were formed, freezing into their mass the rocks and soils upon which they rested. Great fields of ice also stretched away from the base of hills and mountains from whose sides the avalanche came thundering down, loading the ice with rocks, ores and the loose material of the surface. When summer came, the ice, released from the shores where it was formed, and moved by currents setting southward, bore away its burden and dropped it from place to place as it slowly melted away.

There is reason to believe that sudden elevations of great masses of land in distant portions of the globe also occurred during this period, causing immense waves to rush with tremendous force over the submerged lands, and transporting the rubbish of the ocean bottom from place to place. Thus we can explain the distribution of those scattered primary iron ores, and pieces of native silver and copper, in company with boulders of igneous rock, from Lake Superior, south across Wisconsin, as far as Springfield, Illinois.

We know that these and other ores occur abundantly in the region around Lake Superior, and we have only to recur to the changes through which our globe has passed, to account for their transportation hither. The ice-bergs of an ancient ocean were the first explorers of our northern mines.

They, tore open the stony treasuries of nature with their giant arms, and seizing upon the glittering ore bore it away only to scatter it in their sport over the ocean floor.

The ocean has returned to its limits, and we now find our home on the very spot where its waves once rolled. The wandering red man picks up these scattered metals and treasures them as charms and fetishes, or fashions them into arrows and hatchets, and his civilized brother, the white man, founds upon their discovery extravagant visions of wealth.

From this explanation, (which I have made because it is a subject of very frequent inquiry,) it will be seen at once that no valuable expectations can be safely based upon the discovery of these isolated fragments of ore. Where, however, pieces of ore are found very abundantly, and especially where they are not accompanied by boulders or drift gravel, they may be the float of some deposit not far away, and justify a careful examination.

The deposits of bog ore are very numerous in the swamps and marshes of the State, but I have found none as yet of sufficient extent or richness to be of value. It is quite important that these ores should be discovered here in quantity, as they are valuable to mix with the harder and richer ores.

They generally occur near the edges of marshes, and may be easily recognized by the appearance of ochre or iron rust which they present. Their extent may be readily ascertained by sinking a few test pits over the low grounds to a sufficient depth.

I shall proceed now to speak of those deposits of ore which are likely to become valuable as a basis for the manufacture of iron in our State.

### ORES OF THE IRON RIDGE—DODGE COUNTY.

The principal part of this ore is located on sections 12 and 13, in the town of Hubbard. It occurs in the form of a bed, interposed between a massive grey limestone above and a soft blue shale below.

It makes a presentation at the surface along the outcrop of these rocks for more than a mile, and dips conformably with them eastward. Its greatest thickness is at the eastern end of the bed, where the limestone has been removed and the whole mass has crumbled down so as to be shoveled up like dirt. It is here about 25 or 30 feet thick, but where it lies in place under the limestone, it ranges from 10 to 15 feet, thinning towards the east.

The underlying shale has been pierced 20 feet in sinking a well, and a hard blue limestone filled with fossils encountered at that depth.

The geological position of this ore is probably very correctly stated by Col. Whittlesey, who visited it while connected with the U. S. Geological Survey.

He refers it to rocks of the same age as the Clinton group of New York. The base of the ridge along which the sandstone, the ore, and the upper part of the shale present themselves, is covered deeply with drift, and no rocks are seen upon the surface for several miles in any direction.

North and west about 8 miles, the Trenton limestone is found, capped by 15 feet of Galena limestone. These rocks *dip eastward* and a careful examination of the ground proves clearly that the upper surface of the Galena limestone cannot be more than 40 or 50 feet below the ore bed at Iron Ridge. This fact serves to point at once to the equivalency of the blue shale with that which overlies the Galena limestone in the lead region of the State.

I discovered that shale first in 1851, and afterward noticed it in my first annual report upon the geology of Wisconsin in 1853, under the designation of "Nucula Shale." It seemed to have been previously overlooked by the geologists who had visited the mines on account of its very general removal by erosion. Notwithstanding its great importance as one of our formations, (attaining as it does a thickness of 60 feet,) when its soft and perishable nature is considered, it does not seem strange that it was not observed before. It forms the base of the large conical "mounds" or hills of the mining region, and its position can readily be ascertained by the springs, which mark it everywhere. Its lower portions there are highly fossiliferous, and contain pyrites and occasional seams of beautiful crystalized gypsum. It is very finely exhibited in the great cut at Scales Mound on the Illinois Central R. R., just south of the State line. It is not seen east of Blue Mound until we encounter it at Iron Ridge.

In the west it is capped by about 400 feet of limestone which form the upper strata of the "mounds." These limestones contain abundant fossils, and were first properly located by Prof. Hall in the upper silurian, the equivalents of the Clinton and Niagara groups of New York. They are evidently identical with the limestones which form the upper portion of Iron Ridge, and which extend thence uninterruptedly south as far as Joliet, Illinois, and north nearly as far around the shores of Lake Michigan.

The shales are also identical, and have been recognized by Prof. Hall in Foster and Whitney's Report on Lake Superior and district, as belonging to the Hudson River group. The geological position of this ore and its accompanying rocks may therefore be considered as settled. The limestone above the ore is a coarse cavernous sub-crystalline rock, in layers from 4 idches to a foot thick. It is intersected by very large open fissures, which extend back some distance from the ledge, and can be seen ramifying in all directions on the thinly covered surface.

I observed similar fissures in the same formation, on the east shore of Green Bay, above the Bay Settlement. This rock at Iron Ridge contains but few fossils, and those mostly casts. It is a magnesian carbonate of lime, quite pure.

The physical character of the Iron Ridge ore is different from that of any other deposit known in this country. It is apparently related to the oolitic ores, though it differs from any of them that I have seen described. It consists of small grains or concretions, varying in size from a mustard seed to four times as large, quite irregular in shape, but usually slightly oval and flattened to a disc. Color bright red, with a glistening polished surface, which feels greasy to the touch and stains like red chalk.

These grains are apparently concretions formed around minute particles of silica, as is shown in Dr. Jackson's analysis. Their flattened form seems due to gravitation. The deposit is unquestionably of aqueous origin, but I have as yet found no fossils in it nor do I know of any being found by others.

When found in place, the grains are cemented together into a moderately firm mass, which is regularly stratified like the limestone above, and intersected by joints and cleavage planes. The grains lie flatwise parallel with the bedding, and are occasionally mingled with nodules of very compact hematite, which seems to have been formed by chemical changes, induced since the original deposition of the ore. These are of various forms and sizes and have the color and glistening surfaces of the small grains.

Where the limestone has been removed, the cohesion of the particles is soon destroyed by atmospheric agencies and all traces of stratification disappears. A large quantity of ore has been thus partially decomposed, and in some instances washed down the hill side and formed a subordinate deposit. In some cases it has mingled with clay, and forms an excellent red chalk and mineral paint.

This loose ore is known as "seed ore" among the furnace men who work it.

The limestone in contact with the ore bed is often filled with cavities containing crystals of specular ore and pyrites, and much iron is diffused through the whole mass.

The amount of ore existing in this bed cannot of course be calculated with precision. It is safe, however, to estimate a continuous layer of 10 feet over 500 acres of ground, which would give us 27,225,000 tons of available ore, capable of yielding 13,612,500 tons of metalic iron. This bed of ore would, therefore, supply one furnace, producing 10 tons of iron per day, for 37,394 years, or ten furnaces of the same capacity for 3,739 years. It may therefore be regarded as inexhaustible.

The chemical composition of the Iron Ridge ore is a matter of great importance, and as several analyses had previously been made which differed considerably on points of practical moment to the iron interest, I thought best to have a new examinotion. I therefore submitted this ore to Dr. Charles Jackson, of Boston, whose distinguished reputation both in this country and Europe, invests his results with authority wherever they may be read, and whose large experience in the examination of iron ores, especially qualified him for the task.

The specimens selected were from the ore as it was prepared for the furnace, and where all the qualities of that kind of ore would be likely to present, and Dr. Jackson was requested to spare neither pains nor expense in ascertaining the existence of any substances which would injure the quality of the iron made from it.

The results here given in his report upon specimen No. 3, apply to the great mass of loose ore at the western extremity of the outcrop where the Northwestern Iron Co. obtain their ore.

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STATE ASSAYER'S OFFICE,
32, Somerset st., Boston, Dec. 17, 1857.

PROF. E. DANIELS,
State Geologist to Wisconsin,

DEAR SIR:—I have analyzed sample No. 3. of the iron ores you left with me, and have obtained the following result.

It is an oolitic iron consisting of flattened grains, the spheroids having grains of quartz sand as nuclei. These grains are cemented together by a clayey like mass of fine ore.

On chemical analysis, made with the utmost care, the following results were obtained per cent.:

| | | |
|---|---|---|
| Water, | 8,750 | |
| Silica, | 7,750 | |
| Magnesia, | 0,640 | |
| Alumina, | 8,400 | |
| Oxide of Manganese, | 1,400 | |
| Lime, | 0,560 | |
| Peroxide of iron, | 72,500 | —50.77 metallic iron. |
| | 100,000 | |

This ore was searched for phosphoric acid, sulphur and sulphuric acid, arsenic and arsenious acid, but no trace of them can be discovered. The magnesia and the lime are combined, not with carbonic acid, but with silicic acid or silica. The alumina is combined with silex, forming with the above named silicates a clay, which is mixed with the iron ore. Oxide of manganese, in the proportions in this ore, is beneficial to the iron, and improves the quality of bar iron made from it, giving it a good steel forming quality.

Properly smelted, this ore will make good pig and bar iron

Yours, Charles T. Jackson,
State Assayer.

It will be seen by this analysis that Dr. Jackson failed to find phosphorus in this ore, though careful search was made for it. The ore has long been reported to contain that noxious substance, which was supposed to cause the brittleness seen in castings made from it, when cold.

It is the opinion of Dr. Jackson that this brittleness is caused by the silex which forms the nucleus of the grains of ore, and which, from its intricate combination, is not separated by the ordinary process of reduction. He recommends a mixture of calcareous ores, or a flux of lime, with careful experiments as to amount of materials. This peculiarity does not injure the ore for bar iron or steel, and its composition is eminently favorable for those purposes.

The location of this bed of ore is such as to make it the basis of an extensive manufacture of iron. It is encircled in all directions by heavy hardwood timber, most of which will be tributary to the furnaces, furnishing charcoal cheaply and abundantly for a long time to come.

It is but 40 miles from Lake Michigan, with which it is connected by the Milwaukee & La Crosse R. R. This road runs directly through the ore bed, and furnishes means of transportation for the iron east or west, connecting with other lines at its termini and along its course. When the present stock of fuel shall be exhausted, coke from the coal beds of Illinois can be brought to the ore, or the ore carried to the coal at a trifling expense above the present cost of charcoal.

All the materials that are required for fluxes, lime, sand and clay, are found in great abundance near the ore bed.

The expense of mining the ore is trifling, not exceeding 12 1-2 cents per ton. It requires no roasting, and yields its iron by the simple application of heat in its original state.

The Northwestern Iron Company have a blast furnace in operation at Mayville, 4 1-2 miles from the ore bed. This locality was selected on account of the water power, which they use in driving their blast and other machinery.

They make a ton of pig iron from two and a quarter tons of ore, allowing for all waste in manufacture. They have also an extensive foundry just completed, where they are making water and gas pipe, lamp posts, building fronts, and heavy castings generally, at prices which defy all competition. They are able now to supply the home market with castings of the best quality made directly from the ore.

The product of their last blast was 3528 tons of pig iron. They are preparing to erect extensive works at the ore bed as soon as the demand for iron shall justify it.

There can be no reasonable doubt of the feasibility of manufacturing profitably, iron, nails and steel whenever capital enough can be turned in this direction to sustain the extensive works required for such a purpose.

The experiments thus far made, amount to nothing in determining the full value and capacity of this ore, and we are fully justified in placing it, when all its circumstances are conered, at the head of the iron deposits of the Northwest.

In consequence of the failure of the first experiments at Iron Ridge, this ore fell into disrepute, and is even now supposed to be worthless by many who are not familiar with the recent successful results. It should be remembered, however, that nearly all mines of iron and coal, are at first regarded as valueless. Every ore bed presents some new feature, and requires often patient and long-continued experiment to ascertain its true value, and the best mode of rendering it available. It is rare also to find an ore which is valuable for many uses, unless combined with other ores.

Even the best Scotch pig is improved by a mixture with this iron. We may be quite certain, therefore, that as *experiments* shall be made with our ores, either by new combinations or modes of working, latent properties and values now unknown will be developed.

The accompanying certificates from several of the principal iron manufacturers of the west, are the best possible attestations to the value of this deposit of ore. The Northwestern Company deserves great credit for the quiet, persevering manner in which it has proceeded in the development of this great interest. It is now realizing rich returns upon its heavy investments, and promises to be a most profitable concern to its stock holders.

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Chicago, June 11, 1857.

*To the Northwestern Iron Company, Dodge Co., Wisconsin:*

Gents:—I have used in my foundry here, and been acquainted with your pig iron, made in Wisconsin, nearly four years; and can say from its peculiar solidity, and the smoothness with which it runs, that no better pig iron can be procured here for gas, steam or water pipes, lamp posts, etc. For machinery, I find by mixing with stronger irons, it improves the smoothness of the castings, and by its always running solid, prevents the loss of castings, which might occur with more *open* or *porous* irons. Yours respectfully,

Frank Letz.

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Chicago, June 11, 1857.

*To the Northwestern Iron Company:*

Gents:—We have used your iron made in Wisconsin, and can say that from the smoothness of the castings, and its solidity, we consider it a superior pig iron for the manufacture of all kinds of water, gas and steam pipe.

For machinery purposes it requires an admixture of stronger iron, giving the stronger iron solidity and smoothness of surface.

Respectfully yours,

Stone, Boomer & Bouton.

MILWAUKEE, June 12, 1857.

*To the Northwestern Iron Company:*

GENTS:—We have used your pig iron in our foundry in this city for nearly four years, and from our knowledge of its peculiar qualities, can recommend it as being a very durable and superior iron for building purposes, water, gas and steam pipes, lamp posts, etc.

For machinery it requires an admixture of stronger iron, or scrap, but on account of its solidity, and the smoothness with which it runs, it improves the quality of stronger and even higher priced iron.

DECKER & SEVILLE.

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MILWAUKEE, June 9, 1857.

*To the Northwestern Iron Company:*

GENTS:—We have used your pig iron some four years, and from the smoothness of the castings made from it, and its *solidity*, which is peculiar to your iron, we consider it the best article that comes to this market for house building purposes, and more especially for gas, water and steam pipes.

For machinery purposes, when mixed with stronger iron, it gives solidity and smoothness, and improves the same, although too weak to use alone for this purpose.

A. J. LANGWORTHY.

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OSHKOSH, June 8, 1857.

This is to certify that, we have used the pig iron manufactured by the N. W. Iron Co., for three years, and by mixing 1-3 H. R. iron, 1-3 Scotch and 1-3 Wisconsin, it makes an excellent machinery iron. But for building purposes, or for gas, steam and water pipe, the Wisconsin iron manufactured by the N. W. Iron Co., used without any admixture of other *irons*, cannot be excelled by any iron that comes to this *market.*

POWERS, ROGERS & CO.

FOND DU LAC, June 8, 1857.

*To the Northwestern Iron Co., Dodge Co., Wis.:*

GENTS:—We have been using your iron for four years, and find by mixing 1-3 Rossee, and 1-3 strong scrap iron, it makes excellent machinery. No better mixture of iron can be procured in this market.

On account of its solidity and the smoothness of its surface, it is the best quality we know of for building, castings, and especially for gas, water and steam pipe, requiring no admixture with other irons for those last purposes.

WILBER, PEACOCK & CO.

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I have just received the following letter from the Hon. Byron Kilbourn, Superintendent of the Milwaukee & La Crosse R. R. The analyses made by Dr. Chilton agree in the main with those of Dr. Jackson, but they are less complete

ANALYSIS BY DR. JAS. R. CHILTON.

*1st, Hard or Natural Ore—Iron Ridge.*

| | |
|---|---|
| Peroxide of iron, . . . | 77.40—iron 54.18 |
| Silica, . . . . . . . | 9.11 |
| Alumina, . . . . . . | 2.26 |
| Lime, . . . . . . . | 6.72 |
| Magnesia, . . . . . | 0.41 |
| Water—with loss, . . . | 4.10 |
| | ——100 |

*2d, Seed Ore—Or Disintegrated Ore.*

| | |
|---|---|
| Peroxide of iron, . . . . | 79.25—iron 55.47. |
| Silica, . . . . . . . | 6.18 |
| Alumina, . . . . . . | 2.49 |
| Lime, . . . . . . . | 6.81 |
| Magnesia, . . . . . | 0,14 |
| Water—with loss, . . . | 5.13 |
| | ——100 |

MILWAUKEE, January 6, '58

E. DANIELS, ESQ., STATE GEOLOGIST,

DEAR SIR:—Yours of 2d inst. has been duly received. Above I hand you the result of analysis by Chilton, in which you find neither sulphur, phosphorus nor Manganese. The two first I requested him particularly to look for.

I had several experiments made by puddling, and uniformly with excellent results. Whatever substance it is that produces cold shortness in the pig or cast iron, seems to be expelled by the process of puddling, as in every instance we have obtained a first class of wrought iron, without any intermixture of other ores. For railroad iron it is of the first class, and can be produced cheaper at that locality, as I believe, than at any other place in the U. S. This is in consequence of the great ease with which the ore is procured, being at a nearly nominal cost, and the vicinity of a finely settled and productive agricultural region, in which supplies of every kind are to be procured with facility.

I will send you a piece of the bar iron made from the Mayville pig at Fall's village, Salsbury Co., by the first opportunity that offers.

Yours very truly,

BYRON KILBOURN.

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### IRON ORE OF HARTFORD, WASHINGTON CO., AND OF DEPERE, BROWN CO.

At Hartford, 14 miles south-east of Iron Ridge, a bed of ore occurs, having the same physical character and geological position as that just described.

The country between these two points is covered with drift and it is impossible to ascertain whether this is a distinct deposit, or connected with that at the former place. It is probably a distinct bed, as the Iron Ridge ore thins rapidly eastward. This bed attains a thickness of 6 or 7 feet, and is found near the surface in the valley of the stream. It has been struck in digging wells, which have been sunk into it on the town plat, where it occurs at a depth of from 15 to 20 feet from the surface. The bed is not as thick here as at Iron Ridge, and has a less horizontal extent. It is generally covered by the limestone, and very rarely decomposed. Its chemical composition is undoubtedly very similar to that of Iron Ridge.

The same ore is found again 80 miles N. N-E. of Iron *Ridge, in* the town of Depere, about 4 miles east of the village, and about 7 miles south-east of Green Bay. It occurs on the western face of the ledge, which extends along the Fox River and Green Bay, nearly parallel with their vallies.

This ledge is formed by the outcropping edges of the Clinton and Niagara limestones,and at its base, generally concealed beneath the rubbish, the shales of the Hudson River group are fonnd.

At this point a spring brook pours its waters, forming a cascade whose rare beauty rivals even the famed Falls of Minnehaha. The falling water has excavated the underlying rocks, and exposed a clean section, including the upper portions of the shale so generally concealed, and revealing between it and the limestone a bed of lenticular ore 6 1-2 feet in thickness. It presents an occasional outcrop as we trace it along the base of the escarpment for about 200 rods, and is not seen again, as the slope is deeply covered.

It is identical in age, composition and structure with the Iron Ridge and Hartford ores, but the shale seems to be more mixed with the ore than at those places.

Its position in respect to water transportation is very favorable, and as the whole region is covered with forests of hard timber as yet scarcely touched by the woodman's axe, fuel can be easily supplied. It is only 4 miles from a steamboat landing, and its products can be cheaply transported to any western market. The land on which it occurs is mainly owned by Hon.James Howe, of Green Bay, and D. M. Loy, Esq., Depere.

Traces of the same ore are also seen along the ledge northeast of Green Bay, but no considerable deposit occurs.

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### IRON ORES OF BLACK RIVER FALLS.

The ores of this region have hitherto remained almost entirely unnoticed, although their great value justified a much earlier exploration.

They were first discovered by Mr. Spaulding, one of the proprietors of the town, while connected with the Government surveys. They are mentioned by Dr. Shumard, the accomplished palaeontologist, of the Missouri Geological Survey, in Owen's report of 1851.

The Geology of this portion of the Black River Valley presents many points of interest both scientific and economical. The Potsdam sandstone is the prevailing rock, giving origin to the sandy soil which covers the surface everywhere except on the hillsides or in the lowest valleys, where patches of clayey soil occur. The surface is generally level or gently rolling, but occasionally the outliers of the sandstone rise in castellated cliffs and towers of great beauty. These are usually the culminating points of the relief and from their tops magnificent views of the surrounding country can be obtained. At a lower level rounded hills are seen composed of the softer beds of sandstone, or of the primary slates which underlie them.

The Potsdam sandstone contains fewer calcareous bands here than farther east, and is generally soft and crumbling. The configuration of the country is due to the erosion of the sandstone, which once stretched across the broad valleys, as high as the loftiest outliers which now remain to mark the ancient limits of this formation.

Occasional fossiliferous beds occur, one at the base of the sandstone, filled with dim casts of large crustaceans, others at higher levels with lingula prima and lingula antiqua, often so abundant as to compose half the bulk of the layers in which they are found. The decomposition of these shells has had a very important influence upon the soil, redeeming it in great measure from the sterility which is so common where sand predominates. Immediately beneath the sandstone and occasionally rising through it in rounded hills from 100 to 200 feet high we find the azoic and igneous rocks. The former consist of chloritic, micaceous and argillaceous slates; the latter of granite, trap and sienite.

The sandstone gives no evidence of disturbance or metamorphism by heat, but reposes upon the upturned edges of the slates or rounded summits of igneous rocks, with only such slight dips as would naturally result from deposition on an uneven surface. In its lower beds near the line of junction it often contains waterworn fragments of these rocks mixed with pebbles of quartz. The slates and igneous rocks are seen only at comparatively low levels where they have been uncovered by the removal of the sandstone. The igneous rocks are entirely confined to the banks and bed of the river. Very fine sections of the junction of these rocks with the overlying sandstone are exhibited along the river.

The iron ore is associated with the chloritic and micaceous slates of the azoic rocks. It occurs in the isolated ridges or mounds formed by these rocks, and is encountered occasionally over the space of a township. The most important deposit however is located on sections 10 and 11, township 21 north, range 4 west, about two miles above the village of Black River Falls. In descending the river we first meet with this ore, about 50 rods below the mouth of Allen's creek, on the west bank. The slates here rise from the waters edge and present a clean exposure of about 18 feet dipping S. W. 45°. They are very soft and fissile and exhibit a curved lamination. The upper portion of the slope is concealed by debris but the surface is covered with fragments of ore and white quartz and a brecciated conglomerate of sand, ore and slate. Sixty feet above the water the sandstone is seen forming the top of the bluff. This exposure extends about 15 rods and is then covered for a short distance but soon emerges again and rises in a bold cliff 60 feet above the river. It contains here bands of hard massive hematitic ore, from 6 to 40 feet wide. The slates are divided by smooth joints into large angular blocks, and the same joints pass uninterruptedly through the ore, which partakes also of the slaty cleavage. It has often a ligniform structure, occasionally so distinct as to resemble perfectly pieces of fossil wood. Quartz is sometimes found combined with it in alternate layers, giving it a banded appearance. It is usually massive, having a sub-conchoidal fracture, dark grey color tinged with red, sub-metallic lustre, and sometimes magnetic. Veins of red ochre resulting from decomposition are common. From this point the slates and ore sink rapidly towards the south-east, and 40 rods below just emerge from the water. Here they seem to cross the river as they occur on the opposite side, presenting nearly the appearance before described.

The ore has been mined here in the edge of a low bluff on the N. E. qr. of the S. W. qr. of sec. 11, about 65 feet above the river. It is here a mixture of red and brown hematite with numerous nests and seams of ochre, often banded and uniform and at its junction with the slates very siliceous.

It is bounded on the north by very fissile chlorite slate which seems to shade off gradually into the ore. The opening made in the bank displays the connection of the slate and ore very clearly. They both dip conformably 55°, in a direction nearly E. S. E., and are intersected by joints and cleavage planes similar to those on the other side of the river. The surface is covered with ore for about 40 rods south of this opening but no clean exposure occurs.

After passing over a space of a few rods covered with drift, and destitute of ore, we strike a heavy deposit of black oxide highly magnetic. This deposit rises southward and has been quarried for the furnace, so as to present a clean exposure 45 feet high fronting the river, showing a dip of 75° S. E. No rock is seen in connection with the ore here, but it has the general dip of the slates which have no doubt decayed and left it alone. It is mixed with veins and nests of quartz, which separate from it by burning. By this last process it seems to lose its magnetism also.

From this point the ground rises rapidly about 40 rods south, till it culminates in a large hill known as Tilden's Mound, 180 feet above the river. The base of this hill is occupied by chlorite slate, but the upper portions are covered with ore. South of this place no slate or ore is seen but about 12 rods from the base of Tilden's Mound S. W., in the bed of the river occurs a low mound of greenstone trap rising 5 feet above the water, and a few rods farther west are two small islands of the same rock, which are seen in the accompanying section. It is a very heavy, fine grained greenstone, highly ferruginous, and divided by joints into angular blocks and tabular masses. Its proximity to the ore may perhaps have some connection with the magnetic condition, which this portion of the deposit has assumed. West of these trap islands about 15 rods, a light colored reddish sienite, composed of red feldspar and green hornblende, rises 12 feet above the water and forms the lower portion of the river bank. This rock extends with occasional interruptions 3 miles below, sometimes rising 50 or 60 feet above, and again sinking beneath the water. At the falls it extends across the river and forms a natural dam, to which is due the splendid water-power which constitutes the principal interest of the town. At the Falls it is intersected by veins of quartz, in which are occasionally found minute particles of sulphuret of copper.

Small veins of specular iron ore are seen also, often traceable for 20 or 30 rods, accompanied by light colored quartz. the sienite is last seen near Ledyard's mills where a soft, decomposing gneiss or stratiform granite rises 12 feet above the river.

The texture and hardness of this rock are very irregular. It contains seams of quartz which are left by the decomposition of the feldspar and mica, and also scattered specs of copper pyrites. Its dip is about 65°. The lines of stratification are curved near the edges as if bent down by some great weight resting upon them.

Above this rock, and resting almost horizontally upon its upturned edges, is the Potsdam sandstone. The lower layer is a band of conglomerate with micaceous sandstone, succeeded by a thin seam of micaceous shale, and this again by coarse sandstone, which rises to the top of the bank.

The upper portion of the gniess has often decomposed, and in some instances its constituent elements have been recomposed, and have formed a rock beneath the pressure of the sandstone, more enduring than that from which it originated. The product of this chemical change seems to be a sort of consolidated kaolin containing mica, and perhaps chlorite, which it resembles in softness and greasy feel. It cuts readily with a knife, and when polished and wet, presents a beautiful mottled surface, caused by a light colored mineral like feldspar, semi-crystalized upon a ground of green and gray.

Some fine blocks have been cut from it, but the rock is probably too limited and fragmentary to be of any commercial value.

This gneiss continues above the river for about a mile below Ledyard's, where it passes beneath the sandstone a short distance above Shepherd's mill. At this mill a small island of sandstone occurs, composed of the coarse grits which lie just above the granite. The upper layers are filled with casts of very large trilobites, and on a smooth surface of the sandstone, beneath a seam of shale, the tracks of these animals are seen marked by two rows of double impressions parallel with each other. The position of these remains and tracks cannot be far from the base of the lower Silurian, still it is quite possible that the igneous and azoic rocks on which these sandstones rest were hills in the ocean of the Potsdam period, and that older beds have been deposited in its valleys. I have made this extended notice of the geological association of the Black River ores on account of their peculiar and unusual interest.

The accompanying section from the iron works through the ore at Tilden's Mound, and across Black River, will exhibit clearly, its connection with the rocks.

The following analysis by Dr. Jackson, made with great care indicates the quality of these ores:

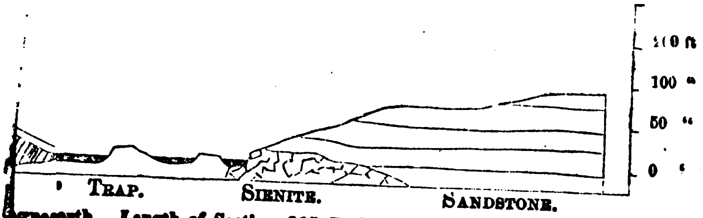
1*st.* *Red Oxide of Iron in ligniform masses.*

| | |
|---|---|
| Water, . . . . . | 1.50 |
| Silica, . . . . . | 26.75 |
| Oxide of Manganese, . . | 3.65 |
| Peroxide of iron, . . | 67.50—47.27 metallic iron. |
| Loss, . . . . . . | 60 |
| | 100.00 |

2*d, Specular and Magnetic Iron ore.*

This specimen was analyzed only for iron. It yielded:

[illegible] 36



greeorth. Length of Section 215 Rods.

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| | 100.00 |

*2d, Specular and Magnetic Iron ore.*

This specimen was analyzed only for iron. It yielded:

| | |
|---|---|
| Silex, . . . . . . | 36 |
| Peroxide of iron, . . . | 64 |

"It therefore contains 44.82 per cent. of metallic iron. It is a good ore to smelt with calciferous ores, or with rich hemetites. Alone it will require a large proportion of lime for a flux.

Oxide of manganese in the proportion found in these ores is beneficial, and improves the quality of bar iron made from them. Properly smelted, these ores will make good pig and bar iron."

These ores are very accessible and can be cheaply mined. They are located within 4 miles of flatboat navigation to the Mississippi, and on the line of the Land Grant Branch of the La Crosse Railroad.

Though the region around is mainly occupied by pine timber, bands of hard wood occur which will furnish a considerable supply of charcoal. It will not, however, be sufficient for an extensive and permanent manufacture, as iron cannot be made profitably with pine charcoal in this country. Some other supply of fuel must be sought for permanent uses, and the cheapest and most reliable will no doubt be found in the coal seams of northern Illinois, with which it would be well to secure an early connection. This can readily be done through the Mississippi River to Dubuque, and thence by the Illinois Central Railroad, and thus an inexhaustible supply of fuel secured, with an outlay very much less than required by the purchase of timbered lands, or the transportation of charcoal.

An enterprising German Company have recently erected a blast furnace, driven by water, on the east bank of the river. They mix the red oxide and magnetic ores, and flux with lime.

They have attempted to use hearths from the Potsdam sandstone of the neighborhood, but have failed to make them work, on account of the lime which they contain.

They have also burnt out a hearth from Amherst, Ohio. In consequence of these failures they have not yet made much iron, but the results are so far highly satisfactory.

. From their experiments the following facts are ascertained: Two tons of the ore will yield one ton of pig iron; cost of mining, $1,50 per ton, including delivery at furnace; twenty per cent. of lime required to flux the ore.

An approximate estimate of the amount of ore at this point will be entirely safe at the following figures:

West bank of the river, on land owned by Darrow and Curts, 15,000,000 tons; east bank of the river, 28,000,000 tons, including the Iron Company's location and Tilden's Mound, giving an aggregate of 43,000,000 tons of available ore.

Other deposits exist in the vicinity, which will no doubt be valuable in time, but which are less favorably located for present working.

This locality is well worth the attention of iron masters and capitalists, on account of the accessibility and superior quality of its ores.

It is also a good agricultural region, and lands may be obtained very cheaply for farming purposes. The soil, though less durable than in some localities, is warm, quick and easily worked, and the adjacent pineries furnish an excellent market for the products of the farm.

## BROWN HEMATITE OF IRONTON, SAUK COUNTY.

This ore is located in the town of Marston, on sections 9 and 10, town 13, range 2, east. Its geological position is in the Potsdam sandstone, which occupies most of the surrounding country, capped on the highest points by limestone, (lower magnesian limestone.)

The ore presents itself on the east bank of Tower's creek, and extends from the brow of the hill down its slope, and some little distance into the valley. The surface is covered with fragments over about ten acres, generally small, but sometimes attaining a ton's weight.

Several shafts have been sunk through the ore on the hill-side to the depth of 10 to 20 feet. It was found extending to that depth, mixed with fragments of sandstone and flints, but no rock in place has been found yet in excavating. Large masses of sandstone lie upon the surface, in the fissures and cavities of which veins of fibrous hematite occur; also fragments of very pure white hornstone similarly mineralized.

No clean section can be obtained here, as the entire slope is covered with loose material. It is therefore impossible to state the precise form or extent of this body of ore. On the surface it extends about 60 rods east and west, and 30 rods in width.

The valley of Tower's creek in which it occurs has been worn out of the sandstone, which rises on either side over 300 feet, and is capped by limestone on the west.

The ore was no doubt formed in the sandstone previous to the wearing down of the valley, and by the removal of the rock in which it was once contained, has been left scattered upon the surface, or mingled with its rubbish.

No marks of volcanic action are seen in the vicinity. The strata of the sandstone are undisturbed, generally soft and crumbling, but furnishing some layers hard enough for good building material.

Some very fossiliferous bands occur, filled mainly with trilobites, rarely however well preserved.

The specimens collected for analyses were not forwarded to me in time, and I cannot therefore present in this report the composition of the ore.

It is, however, clearly a hydrated brown oxide, quite pure, generally massive, but frequently stalactite and mamillary, often assuming beautiful imitative forms. In the seams it is fibrous, and sometimes banded. It occasionally contains small pebbles of quartz, intimately mixed with the ore like a conglomerate.

It will yield 45 per cent of metallic iron. It is safe to estimate its amount as equal to a solid bed 5 feet thick over 10 acres, which would give us 272,500 tons of ore.

The country around is heavily timbered, and lime and other material needed in a furnace convenient.

Jonas Tower, Esq., an ironmaster of large experience and great practical skill, has erected a small blast furnace, capable of producing about 3 tons of iron per day, and intends to manufacture stoves, castings, etc., on the spot. The amount of ore is of course too small for an extensive or permanent business, but will do well to supply the local demand.

I observed a similar ore in the same geological position, in the tunnel west of Tomah, on the La Crosse Railroad. The top of the hill above the tunnel is covered with fragments, which occur also occasionally in the dirt thrown out of the excavation. Large fragments of white hornstone, intersected by small seams filled with black hematite, are common from Garrisonville, on the Baraboo, westward and northward as far as Black River. They are also frequently met with, east of the Wisconsin as far as Lake Mills, Jefferson county.

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## SPECULAR AND TITANIFEROUS IRON OF BARABOO.

The lower part of the Baraboo valley is one of the most *interesting* portions of the State. In variety and picturesque beauty of scenery, it cannot be surpassed in the west. The Potsdam sandstone has here been violently disturbed, and in some cases changed, from a soft crumbling state into a very hard quartzite, usually of a red color, but often grey or banded with red and white. Ranges of this quartzite extend often several miles, and form lofty hills with preciptious escarpments. The high bluffs of the Baraboo at the Narrows, at Spirit Lake, and at Garrisonville, are mainly composed of quartzite.

At the latter place, just back of Mrs. Garrison's house, the quartzite forms the top of the bluff, while at the base, the sandstone seems only slightly changed, and furnishes a building material of excellent quality.

On the opposite bank of the river the rock is unchanged, but a band of limestone occurs in it so pure and extensive as to be quarried and burnt for lime. This is located on land owned by Mr. Eiky, and is the only instance of the discovery of good lime in the Potsdam sandstone of this State.

The quartzite is magnificently developed at Spirit Lake, where it rises 500 feet above the water, in almost perpendicular cliffs, whose lower portions are concealed by huge masses which have fallen down from above.

Veins of milky quartz, sometimes containing geodes lined with fine crystals, traverse the quartzite in many localities, without any constancy of direction. Associated with these are also veins of specular and titaniferous iron ore.

This ore is very irregularly distributed, but follows the general course of the quartz in its passage through the rocks. It is not, however, confined immediately to the vein but isolated bunches of it occur in the quartzite adjacent to the vein.

It is usually made up of thin laminæ, slightly waved and cleaving readily apart. The planes of lammation intersect each other in all directions, giving to the mass an appearance like some of our lead ones.

It is very brittle, slightly magnetic and has a brilliant submetallic luster and lead grey color. No perfect crystals occur but crystalline faces are occasionalls observed.

I have examined these veins with considerable care but have been unable to discover the ore in sufficient quantity to be of value. It was supposed by some to contain silver and analyses were reported to have been made which discovered a large per centage of that metal. I therefore submitted it to analysis, and it proves to be a specular and titaniferous iron ore, containing some tungsten.

This mineral is usually associated with igneous rocks, and volcanic emanations, and may have been introduced by the same agencies, which have vitrified and upheaved the sandstones of the Baraboo.

The region in which it occurs deserves a careful and minute study, which it will be my aim to give it at an early period.

The ores that I have described include all those of any considerable value yet discovered in the acoessible portions of the State.

From specimens brought to me and informatirn gathered from reliable sources, I have reason to believe that large and valuable beds of ore exist in the unsettled districts of the North.

These deposits are valueless now on account of their distance from navigable waters, or other modes of transportation.

This region is now about to be opened by the Chicago Fond du Lac and Lake Superior R. R., and the means will thus be furnished for bringing the resources of this hitherto neglected and almost unknown country within reach.

A thorough exploration of the Western portion ot the State will be the first work of the survey next season.

### MANUFACTERE OF IRON IN WISCONSIN.

It has been shown that we have an abundance of good ores capable of being cheaply mined, reduced, and transported.

It is proper now to consider to what extent these ores can be profitably used in the manufacture of iron in our State.

The question fairly stated is this: Can iron be made from these ores, on the ground, as cheaply as iron of the same quality can be imported from those mines, which now mainly supply our market.

A comparison of the cost of making iron here, and the cost of imported iron, will enable us to reach a conclusion not far from the truth in prosecuting this enquiry.

Unfortunately, however, the elements of such a comparison are deficient on our side, as the production of iron thus far has been confined to a single furnace which has only been in operation a short period and devoted wholly until recently to pig metal. Still enough has been done to indicate the feasibility of a large home production, when our iron works shall have become fully established. The following estimates will show what can be done here in producing pig iron.

Estimate of the cost of producing a ton of pig iron from the Iron Ridge ore:

| | |
|---|---|
| 2 1-4 tons of ore at 75 cts per ton. | $1 70 |
| 150 bushels of charcoal at 5 cts. per bushel. | 7 50 |
| Fluxes if used. | 1 00 |
| Labor. | 4 00 |
| Carting iron to R. R. dept. | 50 |
| Management, Interest on capital, &c. | 1 00 |
| | $15 70 |

Cost of producing a ton of iron from Black River ore:

| | |
|---|---|
| 2 1-2 tons of ore at furnace. | $1 50 |
| 170 bushels of charcoal | 8 50 |
| Fluxes. | 4 00 |
| Labor. | 4 00 |
| Cartage to flat boat per ton. | 50 |
| Management, Interest on capital, &c. | 1 00 |
| Total. | $19 50 |

The cost of iron at Black River is increased nearly $4 per ton over that of Iron Ridge, by the expense of lime for flux, and also of fuel. A considerable reduction in these items will take place when the railroad communication is perfected to that point. As to the local market, its inland position will afford it a protection quite equal to this increased cost.

These estimates will not vary much from the actual results, though in some minor particulars they may be found incorrect, as the cost of labor, fuel, &c. is subject to fluctuation.

The following figures show the cost of making pig iron in those districts where it can be produced most cheaply at present, and which consequently control the market:

| | | |
|---|---|---|
| Scotland. (scotch pig.) | per ton. | $12 50 |
| England and Wales. | " | 18 75 |
| New York. | " | 18 50 |
| Ohio. | " | 18 00 |
| Pennsylvania. | " | 16 00 |

To these prices we must add transportation and duty to the foreign iron, and transportation to the American iron.

The former at present quotations, are selling at 28 to 35 per ton and the latter, about 30 to 33. As prices are now ruinously low, we may safely take these figures in our comparison. According to these prices we have an advantage of from $10 to $18 per ton, over any other furnaces whose products are sent to our market.

An expenditure of $10 per ton more than the cost of pig iron, turns the ore into castings of every description, without the expense of smelting.

The manufacture of bar iron has not been attempted as yet in our State, and the impression seems very general that we must always import it from abroad. It is difficult to find any support for this conclusion. The capacity of our ores to produce good bar iron and steel is undoubted, and there is nothing in the nature of things to prevent their being used for these purposes,except the want of capital and skill,to bring out thier latent value.

The making of bar iron is neither so intricate nor so expensive a business as to be monopolized. The following condensed remarks from " Overmans Treatise upon the Manufacture of Iron" will enable those not practically familiar with this subject to judge for themselves, as to the practicability of establishing this branch of iron manufacture.

"Pig or crude iron is converted into wrought or bar iron by refining, forging, or drawing.

Considerable wrought iron is also manufactured directly from the ore.

The difference in the quality of wrought iron cousists mainly in its different degrees of ductility and malleability. Good wrought iron is nearly pure iron with a mechanical admixture of cinder. In most kinds of commercial iron we find from one quarter to one half per cent. of carbon, more or less sulphur, silicon or silex, phosphorus, manganese, and in all Swedish iron, more or less arsenic.

The nature of wrought iron is seen by examing the operation of puddling. In melting crude iron in a puddling furnace it comes in contact with cinder, containing oxides of iron manganese. In mixing the fluid or semi-fluid iron with this cinder, it will cause the oxidation of such substances as are more easily oxidized than iron, which of course diminishes the fusibility of the metal.

Constant work and mixing cinders with it prevents the formation of large crystals, and the metal crystalizes and adheres by cohesion in small particles, forming a soft spongy mass. The large pores in this mass are filled or covered with a coating of cinder, and when compressed by squeezing or otherwise, form a mixture of iron and cinder.

In drawing or stretching such a condensed mass, the crystals are elongated, form threads, and these together with the oxidized matter which keeps them apart form the fibre of the iron. We thus see that the fibre is the result of a particular form of metal, and may be produced with very impure iron, which notwithstanding its impurity, may be very strong,

Strength depends upon the fineness of the fibre. In many parts of the United States wrought iron is manufactured direcly from the ore in bloomery fires.

Large quantities of iron are made in this manner in New England, New York, Pennsylvania, New Jersey, Michigan and other States.

A small capital only is required to work these forges, and where ore is cheap they are profitable. The quality of the ore determines in a great measure both the quantity and quality of the iron. Only rich ores can be used with success. A large bloomery will make about 2000 pounds of iron daily, at a cost of about $35 per ton. This article is generally purer than puddled iron and very suitable for small iron. This mode of manufacturing is sometimes called the Catalan method.

All experience however has shown that first rate pure and uniform iron cannot be made directly from the ore nor from hot blast iron in competition with the foreign prices. The iron most in demand and for which best prices are obtained is wire iron, steel iron, and iron for the use of hardware manufacturers.

The cost of making iron of course varies very much, and the following estimates are only applicable in a general sense.

Ore is obtained in some localities at 75 cents a ton of 2240 lbs., in others it costs $4, and even higher prices are paid.

Hematites and all hydrated oxides work cheapest in the furnace. The ease of melting one kind of ore so much exceeds that of others, that a very marked difference in price is no objection to using the most expensive kind. Some furnaces in New England pay as high as $10 per ton for ore, but it is not uncommon to see sufficient ore for a ton of iron brought to the furnace for $1.

The amount of flux (which in most cases is limestone) varies from 1-2 to 1 1-2 tons to a ton of iron, and is furnished at from 50 cts. to $5 according to location. Fuel differs much in price and quality. From 130 to 200 bushels of charcoal are required to smelt the ore for a ton of iron, the price of which ranges from 5 to 8 cents per buushel. One ton and three quarters to two tons of anthracite, answer the same purpose.

In case raw bitumunous coal is used an amount equal to that of anthracite is required; and as this coal may be obtained very cheaply in some of the Western States, the advantages of that region for manufacturing iron are very obvious. An equal amount of coke to anthracite is required per ton. Smelting a ton of coke iron, where the coking is included, costs $3 to $4 per ton. Iron may be refined in a run out fire with a loss of 8 to 10 per cent., the use of half a ton of coke 60 bushels of charcoal, and at an expense of $1,00 for labor, and $1,00 for general expense. Puddling is done from $3,00 to $4,50 for labor per ton of iron, with a waste of 3 15 per cent. and consumption of 1400 pound of coal. When the balls are hammered, the hammer man receives $1,00 per ton. Drawing of the blooms into rough bars costs about 40 cents a ton.

In re-heating, from 3 to 10 per cent. of iron is burned, 400 pounds to one-half ton of coal used, and 50 cents to $1,00 in wages is paid to furnace men. The drawing at the rollers costs in wages about $1,00 for heavy bar, $2,00 for common bar, and $5,00 for small iron. The general expenses in a rolling mill are high, because of the extensive machinery, heavy capital, and vicissitudes of trade. It may not be too high if we assume $6,00 as an average expense per ton of bar iron.

The expense of rolled sheet iron can hardly be estimated correctly, but $10,00 per ton for fuel and wages may be near the amount. The amount of iron produced in the United States is estimated at about 800,000 tons per annum. The labor of 250,000 persons is required to manufacfure it. The consumption of iron is 1,100,000 tons annually,—300,000 tons of which are imported from Europe. One-third of all the iron manufactured in the United States, comes from Pennsylvania, whose furnaces are capable of yielding 500,000 tons per annum.

From the above remarks it will not be difficult to calculate nearly, the cost and conditions of making iron, at any given locality. Let us now examine the prices of bar and rolled iron with which our furnaces and forges must compete. The present New York quotations are as follows:

| | | | | |
|---|---|---|---|---|
| English bar, | $ 55 | to | $70 | per ton. |
| American rolled, | 60 | | 62 | " " |
| Swedes iron, | 100 | | | " " |
| Railroad iron, | 65 | | | " " |

About $12 per ton must be added to these prices, for transportation to our market.

The following table exhibits the prices of English bar iron during 7 years, from '43 to '50. They were prepared by the U. S. Treasury Department:

| | | | |
|---|---|---|---|
| 1843, | $57,45 | 1847, | $65,17 |
| 1844, | 53,12 | 1848, | 56,83 |
| 1845, | 58,05 | 1849, | 44,57 |
| 1846, | 74,76 | 1850, | 43,12 |

This table covers a period during which iron was lower, than ever known before or since, and we may safely calculate its average as expressing the full extent of competition, which the American manufacturer must encounter.

The price of railroad iron ranges from $50 to $80 per ton in New York. It is mostly brought from England and is usually made of an inferior iron. Considerable railroad iron has been made of late in New Jersey and Pennsylvania. A very general opinion seems to have obtained, that the manufacture was very complicated and difficult. This opinion is without foundation. Mr. Overman remarks that "the making of rails may be considered the most pleasant and easy branch of iron manufacture."

There is no good reason why every mile of western railway should not be laid with Wisconsin iron.

Upon the home manufacture of railroad iron I am glad to be able to quote such authority as that of James Buchanan, the present Chief Magistrate of the United States. The following remarks were made by Mr. Buchanan, on the floor of the U. S. Senate, in 1844:

"*Railroad* iron is not to be confounded with articles of trade. It comes in to form the material of our highways, stretching over thousands of miles, and to be lengthened still more from year to year; not simply to be constructed once, but to be renewed from time to time.

"It is not more possible for any country to sustain itself under a course of importations for such a purpose, than in the importation of materials for its houses, and the fences on its farms. Whatever measures are required, to secure the early and effectual manufacture of this article here, should be promptly applied. But it has been asserted that railroad iron has not been, and cannot be, manufactured in the United States, even at present prices, the duty included.

"But why has not this iron been manufactured in our country? Is it for want of capital, skill, or enterprise? Surely this will not be contended. There is no mystery in the manufacture of railroad iron. It is a very simple process. We are informed by Mr. Oakley, of the New Jersey Iron Co., that, 'there is no difficulty in making railway iron, or much less than in making many other kinds, which have long been produced in this country.' All that I have heard or read upon this the subject, coroborates the truth of this opinion.

"I confess, sir, that I have a little American feeling upon this subject. As an American citizen, I cannot brook the idea that we shall be dependent upon Great Britain for the very materials necessary to construct the roads on which we travel. Surely, American railroads ought to be constructed of American iron."

These sentiments are the expression of a genuine patriotism, and do honor to their distinguished author.

The market for our iron is by no means confined to our State. There are no valuable iron ores in the Northern part of Illinois, in Eastern Iowa, or in Minnesota, as yet discovered. We have thus an extensive district, much of it already densely populated, and all of it capable of sustaining a dense population, which can be supplied with iron from our ores, more cheaply than from any other quarter. This district includes the great cities of Milwaukee, the metropolis of Wisconsin, and Chicago, the metropolis of the Northwest, and holds a popupulation of 2,100,000 people. Its annual consumption of iron in various froms of ordinary use, cannot be less than 22,000 tons Allowing it to build 300 miles of railroad per annum, and adding the consumption of iron in rerolling of old track upon the 2,000 miles of road slready completed, once in ten years, and the annual demand for railroad iron will not fall short of 35,000 tons. The entire demand for iron will therefore be about 57,000 tons, the market value of which will be not less than $2,280,000.

This may seem a very large amount in the aggregate, but let any one sit down and calculate the amount of iron in all the stoves, ploughs, tools, machinery, pipe, railroad bars, and other fabrics of iron, used in the four or five great States which we may include in the limits of our market, and he will soon convince himself that it does not exceed the actual consumption.

This extensive demand will of course increase with the population, wealth, and facilities of intercommunication. New applications of iron are constantly being made, and these will be more numerous with the advancing civilization of the West.

But whatever extension this demand may take, our capacity to supply it will never be exhausted. We have ore enough above water, and within easy reach, to make 14,000,000 tons of iron. At 100 tons per mile, this would build five lines of railway around the globe, and still leave enough for 15,000 miles at home. The entire annual consumption of the United States, could be supplied from our ore beds 12 yesrs, without exhausting them.

Suppose the four States of Wisconsin, Illinois, Iowa and Minnesota, to use 60,000 tons annually, we could supply these States with their iron for 233 years.

Our fuel too, is no less inexhaustible. We have an immense wooded district in the north from which charcoal can be obtained for present wants. A little distance south of our *border, in Illinois*, lie the exhaustless coal beds of the great

La Salle basin, from which *must* come our permanent supply of fuel* for the reduction of ores, and the heavy processes of manufacture.

We have cheap motive power, abundant facilities of water and railroad transportation, fireclay, fluxes, and every material requisite for manufacturing iron.

With bounteous hand the Great Providence has filled the earth beneath our feet with ores, stowed away in its secret repositories, or spread out upon its suaface, exhaustless supplies of fuel; scattered in profuse abundance fluxes of every kind; dammed up the channels of the rivers for water powers; and above all, conferred upon man the inventive intellect, to combine and organize all these elements, and evolve therefrom a thousand forms of use and beauty. We have as yet scarcely begun to learn the extent of these magnificent provisions. We send thousands of miles to foreign lands for iron rails, and lay them down over our beds of ore. We turn over the soil, red with iron, we stir and cultivate it, with ploughs, and harrows, and hoes, made of foreign stock. We thus in our ignorance, insult nature and spurn her richest gifts. Why should we thus waste the best portion of our glorious heritage? We have imported into the West nearly 300,000 tons of iron during the last 10 years, worth $20,000,000, at $40 per ton. How much this would have done to build up our own industry, had it have been expended at home!

I am not willing to admit that American skill is so inferior to European, that we cannot find means of converting our ores into articles of the most common use, as cheaply as they can be made three thousand miles away, out of similar material, and brought to our market.

Our elder brother of the Saxon race has come to us to learn many things more difficult than this, and he is proud to acknowledge the debt, for it is in his own family. We taught him steam navigation. We have worked up his iron into locomotives, which have never been equalled for speed, strength, or draft, and which to-day are vindicating American skill and genius *on the iron* highways of Europe.

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*See page 42.

The Old World does tribute to the capacity of our engineers, by employing or consulting them on its grandest works. The American Engineers are reflecting more lustre upon our country's fame abroad, than all its foreign representatives, or its army and navy combined. In the improvements of machinery, and processes of manufacture, in all that gives evidence of progress in science and art, we have stood side by side with the most advanced people across the water.

A few weeks since a small party met, by invitation, at the magnificent iron works of Francis Alger, Esq., in Boston, to witness the casting of one of those great cannon, which they are daily turning out from that establishment, for the use of the American navy. Among other distinguished persons present were Col. Fremont, Dr. Jackson, and Sir Charles Fox, the latter gentleman an Englishman of great celebrity, and intimately familiar with such operations in his own country.—It was with feelings of patriotic pride, as an American, that I heard the generous Briton applaud the beautiful and connected mechanism of the works, and admit the superiority of the guns to any yet made in England.

Every gun used in the English service is marked condemned, when it has been fired 750 times. Our guns can be safely fired more than twice that number of times. Mr. Alger is willing to warrant his guns to stand 1,500 charges in proving. (The theory is that every cannon will burst sooner, or later, as each discharge changes the crystilization of the iron and weakens it. Hence the danger of using old condemned guns, at celebrations, &c.)

His guns are made entirely of American iron, and he has succeeded in giving it this wonderful tenacity, by combining scientific knowledge and practical skill, in a course of long continued and careful experiments.

With such results as these before us, we cannot doubt that our country can achieve its independence of foreign sources of supply, in its iron fabrics. In this work our young State, *so full of* energy and capabilities of good, must do its part.—

To this end our resources in this direction must be made known; tha value of this interest must be impressed upon our people, and such a patriotic feeling aroused, that we shall give the first preference always to our own iron.

The State in its organized capacity might properly use only Wisconsin iron in the erection of its public buildings, and exempt all iron works from taxation during a reasonable period after their establishment. With such encouragement, and under such a state of public feeling, capital will flow in this direction, and the production of iron and iron ware will become one of the great interests of our State.

We have now only three furnaces, and produce only a few thousand tons of pig metal per annum, but we are to remember that from small beginnings like this, the mighty iron and coal trade of Pennsylvania and other States, has grown up. Anthracite coal was esteemed worthless as dirt, till Yankee ingenuity, a few years ago, found out it could be burned; and the best ores now used were, many of them, tried repeatedly, and pronounced worthless. Time, energy, and perseverance have done all that we see in the iron trade of Germany, of England, and the most advanced portions of our own country. The original conditions are here as favorable as they were at first in those places, which have succeeded so well. They have some advantages over us, and we can boast others of equal value over them.

It is well to consider the value of this trade in sustaining and fostering other branches of industry. Agriculture is the great paramount interest of our State; but its prosperity depends not less upon the marketing, than the raising of crops. All experience has shown that the market created by home manufactures, is far better and more reliable, than any other.

We have a fine illustration of this in our vast pineries, and their influence upon agriculture. Whatever the state of the foreign market, the pineries have always absorbed large quantities of farm produce at high prices.

Look now at the splendid farming district bordering Lake

Winnebago, and the Fox and Wisconsin rivers, studded with beautiful homes and thriving towns, radiant everywhere with evidences of wealth and prosperity, and you have a triumphant vindication of the value of a home market.

The agricultural counties of the central part of the State are quite as much indebted to the lumber interest for their rapid growth in population and wealth, as to their natural fertility and beauty. It is a matter of vital importance to our farmers to secure a market for their surplus products. These products are being multiplied more rapidly than the old sources of demand. The emigrants who once used our surplus, have settled and become producers. The pineries are supplied and the home market is exhausted. The same process is going on in the great agricultural States around us, tending still to aggravate the difficulty. We are thus largely dependent upon a distant market, both as buyers and sellers. Our remedy is to multiply the variety of home products, and encourage home manufactures.

Every ton of pig iron manufactured consumes $10 worth, and every ton of bar iron, $26 worth, of agricultural products. If this iron is worked up into tools, utensils, and machinery the amount of consumption per ton will of course be greatly increased. If therefore our iron mines were worked upon a scale equal to their capacity, and the legitimate demand which they can supply cheapest, a home market of at least $1,500,000 worth of agricultural products would be created.

This vast sum thus kept at home, would not only do much to sustain and advance our agriculture, but to rear side by side with it a diversified manufacturing and mechanical industry, supplying the wants and increasing the comforts of our people.

If we would prosper permanently, we must do everything possible within ourselves. Whatever the Creator as given us in soil, mine, forest, lake and river, that is so much fundamental capital which we are to make the most of, if we would carry out the designs of nature, and reap the reward. When we have improved all our resources to their fullest extent, and exhausted invention in attempts to create new values, there will still be enough that we shall need, and cannot produce, to sustain our foreign and domestic trade, and help to "wind the silken chain of commerce round the world;" and more, what will be well, both for our reputation, and our pockets, we shall then have means to pay our distant neighbors for what we buy of them.

Iron is truly one of the precious metals. Its production enriches without demoralizing. Its returns are sure and steady, coming as the legitimate fruits of capital, skill and labor united to master the secrets of nature, and unravel her subtlest combinations.

Our iron mines are more precious than veins of gold. Spain owning half the New World, sending her ships accross the sea with every favoring breeze, guarded by invincible armadas and loaded with the gold of her provinces, dispised her iron and drove away her craftsmen.

England shut up in her island home, wrought silently among her mountains of iron, and supplied every market with her fabrics and her wares.

Look now at the noble, growing, and benificent civilization of the one: Contrast it with the rottenness and decay, verging fast upon dissolution, of the other.

The expansion and development of our iron interest is well worthy of the serious attention of the State. It will add largely to our wealth, population and prosperity; it will enlarge our material dominion and give us commercial independence, and by introducing a new element into our industry, exert a healthy and prosperous influence upon the inventive genius of the people.

A people devoted to a few simple pursuits cannot permanently maintain a high intellectual character. The varied talents and tastes found in the different members of every family, require each its specific vocation.

A diversified and refined industry, gathers up and distributes every germ of mind, gives to each the place best suited to his capacity, and thus secures the completest education of the general intellect. The rich and varied resources of our State were designed not only to furnish us the means of physical comfort, but also to offer a field for the culture of that higher nature, for whose transient home the great globe itself was brought into being.

### COAL OF NORTHERN ILLINOIS.

I present below a few facts pertaining to the Coal deposits of Northern Illinois, which have an important connection with our supply of fuel; especially that portion of it required for the manufacture of iron.

The most important of these deposits to us, is that located at La Salle, on the Illinois river, about seventy-five miles south of our State line. It consists of three seams, one six feet, one five feet, and one three to four feet thick.

I made, some time since, a thorough examination of this coal district, and am fully convinced that its immense resources can hardly be over estimated. The La Salle coal basin is about twelve to eighteen miles in diameter, and contains not less than 150,000,000 tons of coal. This basin is situated at the terminus of the canal, and at the head of steamboat navigation on the Illinois river. It is also traversed by the Rock Island and Illinois Central Railroads. It has, consequently, the most extraordinary facilities for shipping coal.

The Illinois Central Railroad runs north from La Salle, and connects with the Mississippi river at Dubuque, with the Galena and Chicago Railroad at Freeport, and through it with the Madison and Beloit Railroad, Milwaukee and Mississippi Railroad, and all the Roads which intersect the southern portion of our State. We are thus brought into immediate connection with these coal deposits, from which, at no distant day, we must derive a large share of our fuel.

I extract from the Annual Report of O. N. ADAMS, Esq., the capable Superintendent of the Little Rock Mining Co., the following table of analyses, and accompanying remarks, which enable us to decide by close comparison with other standard coal, upon the value of this.

"The coal of the lowest seam will compare favorably, for manufacturing or domestic purposes, with the best coals of Ohio and Pennsylvania, as shown by the following:

**Comparative Table of Analyses.**

| STATE. | LOCALITY. | DESIGNATION OF COAL BED. | ANALYSIS. Fixed Carbon. | ANALYSIS. Volatile Matter. | ANALYSIS. Ashes. |
|---|---|---|---|---|---|
| Penn'a.... | Blossburg,.......... | Blossburg,....... | 62 80 | 32.80 | 5.20 |
| " | Venango Co.,....... | Sandy Ridge,.... | 49 80 | 43.20 | 7.00 |
| " | Crawford Co.,...... | ............... | 59.46 | 38.75 | 1.80 |
| " | Mercer Co.,......... | ............... | 57.80 | 4[illegible].45 | 1.70 |
| " | .................. | Ormsby,......... | 6[illegible].40 | 33.20 | 2.40 |
| Ohio...... | Summit Co.,......... | Upsons,......... | 53.40 | 44.30 | 2.29 |
| " | Hammondville,...... | Strip Vein<br>1st Analysis,.. | 70.80 | 26.40 | 2.80 |
|  |  | 2d Analysis,... | 65.60 | 29.20 | 5.20 |
| " | Briar Hill,.......... | Briar Hill,....... | 58.41 | 38.13 | 3.46 |
| Illinois.... | La Salle Co.,........ | Little Rock,<br>"Lower Bed,"<br>1st Analysis,... | 53.20 | 44.00 | 2.80 |
|  |  | 2d Analysis,... | 57.60 | 38.40 | 4,00 |
| " | La Salle Co.,........ | Little Rock,<br>"Upper Bed,"<br>2d Analysis,... | 48.80 | 39.60 | 11.60 |

The coal from the Little Rock Company's shaft on the lower bed, has given general satisfaction for all domestic purposes. Whether used in open grates or close stoves it burns freely, leaving but little ashes, and scarcely forming any clinker.

The cost of mining this coal and putting it upon cars or boats, is about $1,15 per ton. As the coal trade assumes magnitude and permanence, it can be raised from ten to twenty cents per ton cheaper than now. This coal now sells at $3 per ton at the top of the shaft; cost of transportation to Chicago by canal, 60 cents per ton!

The demand for the coal during the past two years has been fully double the supply.

Dr. Norwood, the very able Geologist of Illinois, says of this coal district:

"The position of the La Salle basin is not surpassed by that of any other in the West. It is connected with Lake Michigan and the Mississippi river by means of the Illinois river and the Canal. It is also intersected by the Illinois Central Railroad, giving a connection with both northern and southern markets; and by the Chicago and Rock Island Railroad, giving it access to markets both east and west. Thus at no time need you fear an overstock in the market, as you can send your coals in all directions, both winter and summer, and the demand will always be equal to the supply.

The accompanying table of analyses of Illinois Coals, compared with those of other well known coals, will enable any one to judge of their relative value. I send also a table of a few foreign coals, which bear a high reputation among manufactures of iron. I do this because the iron ores of the North are very abundant, and can be made accessible to the La Salle coals.

### NORTHERN ILLINOIS COAL.

| NAME OF COAL. | COUNTY. | Specific Gravity. | Moisture. | Volatile Gases. | Carbon in Coke. | Ashes. | Carbon in Coal. | Color of Ash. |
|---|---|---|---|---|---|---|---|---|
| Watson's Mine...... | Grundy, | 1.259 | 9.0 | 36.5 | 47.8 | 6.7 | 51.3 | Pink. |
| Turner's,* (Morris) | " | 1.227 | 7.0 | 41.5 | 49.0 | 2.5 | 54.1 | White. |
| Marseilles.......... | La Salle, | 1.3144 | 5.0 | 40.6 | 33.4 | 21.0 | 47.0 | " |
| Ottawa,†.......... | " | 1.2672 | 7.8 | 35.9 | 52.3 | 4.0 | 54.6 | |
| *La Salle Basin,* *(Lower Bed,)* | | | | | | | | |
| Ireland's,.......... | " | 1.237 | 6.8 | 39.9 | 50.3 | 3.0 | 55.1 | Grey. |
| Seeley's,.......... | " | 1.2234 | 8.0 | 34.6 | 41.4 | 16.0 | 53.0 | Red. |
| Field & Rounds',... | " | 1.222 | 6.7 | 41.4 | 46.7 | 5.2 | 53.4 | Red. |
| Hartshorne's,...... | " | | 4.9 | 37.6 | 49.7 | 7.8 | 54.16 | Brown. |
| Hitt's,............ | " | 1.2985 | 4.5 | 42.4 | 40.3 | 12.8 | 47.5 | White. |
| *(Middle Bed.)* | | | | | | | | |
| Big Vermillion,.... | " | 1.242 | 12.0 | 39.4 | 47.1 | 1.5 | 54.8 | |
| Kirkpatrick's,..... | " | 1.202 | 7.0 | 41.2 | 49.3 | 2.5 | 54.6 | Grey. |
| Egleston's,........ | " | | 5.5 | 42.75 | 48.45 | 3.3 | 52.53 | Grey. |
| *(Upper Bed)* | | | | | | | | |
| La Salle Coal Mining Co,........ | " | | 6.5 | 36.43 | 50.07 | 7.0 | 54.39 | Brown. |

## ANALYSES OF FOREIGN COALS, USED IN THE MANUFACTURE OF IRON.

| COUNTRY. | LOCALITY. | NAME OF BED. | Volatile in Coking | Carbon. | Ashes. | Color of Ash. |
|---|---|---|---|---|---|---|
| England | Forest of Dean, | Linderford, | 36,00 | 62. | 2. | Red. |
| " | Parkend, | " | 39.00 | 58 5 | 2.5 | Ochre. |
| " | Coleford, | High Delf, | 32 03 | 63.72 | 4 25 | Red. |
| " | Starkey, | | 46.72 | 61.53 | 1 75 | Red. |
| " | S. Staffordshire, | New Mine Top, | 45.100 | 52 775 | 2 125 | Pink. |
| " | " | Fire Clay, | 46 35 | 52.40 | 2 25 | Buff. |
| " | Bentley, | Ten Yard, | 34.18 | 63 57 | 2.25 | White. |
| " | Lane End, (N. Staffordshire) | Bassey Mine, | 38.70 | 58.30 | 3,00 | Pink. |
| " | Lane End, (*best furnace*,) N. Straffordshire, | | 32.30 | 65.20 | 2.50 | White. |
| " | Golden Hill, | Spendcroft, | 39,58 | 58.67 | 1·75 | |
| " | " | Little Row Bed, | 34.53 | 62.47 | 3.00 | Grey. |
| " | Shropshire, | Randle Coal, | 32 81 | 64 19 | 3. | White. |
| " | " | Double Coal, | 41.38 | 57.87 | .75 | Fawn. |
| North Wales | Brymbo | Three Yard, | 35.70 | 62,70 | 1.6 | Light. |
| | " | Brassey Vein, | 34 100 | 64 582 | 1,318 | Grey. |
| England. | Churchway, | | 35.67 | 60,33 | 4. | Brown. |
| " | " | | 34.740 | 64.135 | 1.125 | Fawn. |
| " | S. Staffordshire, | Corbyn's Hall, (Ton Coal,) | 40.6 | 51.9 | 7.5 | Grey. |
| " | " | Corbyn's Hall, (Heathing Coal,) | 43.33 | 54 17 | 2.50 | Buff. |
| " | | (Bottom Vein,) | 32. | 62.870 | 5.125 | Pink. |
| " | " Bentley, | (5 feet Splint Coal,) | 45.83 | 49 42 | 4.75 | Red. |
| " | N. Staffordshire, Golden Hill, | Ten Feet Coal, | 39.11 | 58 89 | 2. | Grey. |
| " | | Great Row Coal, | 37.70 | 60.80 | 1.75 | Grey. |
| " | " | Little Row Coal, | 34 53 | 62.47 | 3.3 | Grey. |

H. C. Freemen, Esq., the skillful mining engineer, and manager, of the LaSalle Coal Co., says in a late report:

"The lower bed compares favorably with coals of high reputation. The middle or six feet bed is scarcely inferior, and its greater thickness will render it more profitable in working. The seam of Cannel coal in connection with it gives it additional value. We have been using this coal for eight months, in our engine, and find it an excellent coal for generating steam. In burning, the residuum is coke and cinders, and leaves the grate bars perfectly free and clear."

Mr. Freemen informs me that the LaSalle coal is now being used at Galena and Dubuque in the gas works of those towns.

There can be no question as to its adaption to iron manufactures.

Bituminous coal is very largely used for this purpose, both raw and coked, in many parts of the globe.

In a letter just received from James C. Clarke, Esq., Gen. Supt. Ill. Central R. R., he states:

"In May, 1856, I ordered some slight changes to be made in an ordinary wood burning engine, for the purpose of testing the practibility of using Illinois coal as fuel for the locomotives of this company. This engine was run upwards of a month doing regular service, making 16,600 miles. The experiment was so satisfactory, that this company ordered 20 coal burning engines, which are now in use. Nearly all our freight trains are run with coal burning engines. They are working well, and give entire satisfaction, at much less cost for fuel than engines burning wood.

The lower vein at LaSalle is quite free from sulphur and other objectional matter. There is no doubt in my mind that it will eventually be used as locomotive fuel in all northern Illinois.

The LaSalle coal basin is being rapidly developed. I enclose a tariff of prices, adopted by this line. You will observe that it is based upon a sliding scale, discriminating in favor of consumers at a distance.

In reply to your enquiry as to "what this company would carry iron ore for; I will say upon the same terms as coal.

We feel dispored to foster the mineral traffic as far as possible. In adopting our tariff, we did not look to the immediate revenues to be derived from the traffic, but rather to the development of the coal fields, and the increase of mining population along our line."

"I speak of this coal matter from an experience of 10 years on the Baltimore and Ohio R. R. and in the coal regions of Maryland."

By the tariff of prices alluded to, coal or iron ore carried *120* and under 150 miles is charged 1 3-4 cts. per ton per *mile; 150* miles or over, 1 1-2 cts. per ton per mile.

The liberal and enlightened policy adopted by the Ill. C. R. R., looks to ultimate rather than immediate results, and offers substantial encouragement to the opening of our mines of coal and iron.

I append a few tables and accompanying remarks, from Overman's great Work upon iron. These are of great value, too, in a practical point of view, both to the public generally and to iron mongers, as furnishing valuable data for judging of the relative value of different kinds of fuel.

The specific gravity of the different kinds of wood, is of the first importance. This is the proper criterion of their value, though wood is generally bought by measurement. Its specific gravity is directly in proportion to its amount of carbon, hydrogen, and oxygen. The following table shows the specific gravity of wood, water being the standard unit, and the relative value of the most common varieties:

TABLE SHOWING THE VALUE OF WOOD.

| Kind of Wood. | Specific gravity of Wood. | Pounds of Wood in a cord, Adp. | Per centage of Charcoal. | Specific gravity of the Charcoal. | Pounds of Charcoal in a bushel. | Bushels of Charcoal from a cord of dry Wood. | Relative value of dry wood. Hickory 1. |
|---|---|---|---|---|---|---|---|
| White ash, | .772 | 3450 | 25 74 | .547 | 28 78 | 31 | .77 |
| White beech, | .724 | 3236 | 19.62 | .518 | 27 26 | 23 | .65 |
| Butternut, | .567 | 2534 | 20.79 | .237 | 12.47 | 42 | .51 |
| Red Cedar, | .562 | 2525 | 24 72 | .238 | 12.52 | 50 | .56 |
| Chestnut, | .522 | 2333 | 25.29 | .379 | 19.94 | 30 | .52 |
| Dogwood, | .815 | 3643 | 21 | .550 | 29.94 | 26 | .75 |
| Shell-bark hickory, | 1.000 | 4469 | 26 22 | .625 | 32 89 | 36 | 1.00 |
| Hard maple (sugar), | .644 | 2878 | 21.43 | .431 | 22 68 | 27 | .60 |
| Soft maple, | .597 | 2668 | 20.04 | .370 | 19 47 | 28 | .54 |
| Magnolia, | .605 | 2704 | 21.59 | .406 | 21.36 | 27 | .56 |
| Chestnut oak, | .885 | 3955 | 22 75 | .481 | 25.31 | 36 | .86 |
| White oak, | .855 | 3821 | 21.62 | .401 | 21.10 | 39 | .81 |
| Black oak, | .728 | 3254 | 23 80 | .387 | 20.36 | 38 | .71 |
| Red oak, | .728 | 3254 | 22.43 | .400 | 21.05 | 30 | .69 |
| Yellow Pine, | .551 | 2463 | 23.75 | .333 | 17.52 | 33 | .54 |
| Jersey Pine, | .478 | 2137 | 24.88 | .385 | 20.26 | 26 | .48 |
| Pitch pine, | .426 | 1904 | 26 76 | .298 | 15.68 | 33 | .43 |
| White pine, | .418 | 1868 | 24 35 | .293 | 15.42 | 30 | .42 |
| Poplar, yellow, | .563 | 2516 | 21.81 | .383 | 20.15 | 27 | .52 |
| Poplar, Lombardy, | .397 | 1774 | 25 | .245 | 12 89 | 34 | .40 |
| Sycamore, | .535 | 2391 | 23.60 | .374 | 19.68 | 29 | .52 |
| Blackwalnut, | .681 | 3044 | 22.56 | .418 | 22. | 31 | .65 |

TABLE SHOWING THE VALUE OF COAL.

| Kind of Coal. | Specific gravity. | pounds of coal in a bus. adp. |
|---|---|---|
| Lehigh coal, | 1.494 | 78.61 |
| Schuylkill, | 1.458 | 76.46 |
| Susqehanna, | 1.378 | 72.25 |
| Rhode Island, | 1.438 | 75.67 |
| Cannel Coal, | 1.240 | 65.25 |
| Liverpool, | 1.331 | 70.04 |
| Richmond, | 1.246 | 65.56 |
| La Salle coal, | 1.416 | 75.42 |

The value of wood by measure, corresponds directly with its specific gravity after being dried in the kiln. Oak is, therefore, worth nearly as much again as pine for making charcoal.

This subject deserves the close attention of the Iron Master, for it is his business to select wood, and regulate its price according to quality. If a cord of hickory is worth one dollar, white oak is worth 77 cents, beech 65 cents, sugar maple 60 cents, white oak 81 cents, pine 54 cents, &c.

The comparative value of coal and wood may be gathered from the following table carefully prepared, and indicating the results of numerous experiments:

Coal at $5,25 per ton, equals best wood at $2,28
" 5,50 " " " 2,39
" 5,75 " " " 2,50
" 6,00 " " " 2,61
" 6,25 " " " 2,75
" 6,50 " " " 2,83
" 6,75 " " " 2,94
" 7,00 " " " 3,06

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## OBJECTS OF THE SURVEY.

A few general remarks upon the Geological Survey, may not be out of place at the close of this report.

*The* obects of this survey are to ascertain the character, *position, thickness*, and horizontal extent of the various beds of rock that occur in our State; to discover the location, quality, mode of occurrance, and amount of all valuable mineral substances; to examine the soil in various localities with a view to its agricultural capacities, uses, and the best means of improving it; and, in general terms, to collect, arrange, and publish all knowledge that can be obtained of the physical resources of Wisconsin.

By this means our own citizens, and the world at large, will be furnished with reliable information concerning our natural endowments as a State. The dissemination of such knowledge will invite population, hasten the development of our known resources of wealth, and at the same time open up new mineral treasures, as yet undiscovered. In this way every citizen is to be a sharer in the substantial benefits of the survey, and has a direct interest in its successful prosecution.

To accomplish these objects, the Geologist must visit every part of the State, and make the best examinations possible with the means at his disposal. In a State so large as ours, this must occupy considerable time, and therefore it is important that where points of special interest or value occur, they should be early noticed. In this particular, as well as in others, the co-operation of the citizens of the State will be of great value. If every intelligent person would carry out the following simple suggestions, he would not only be accumulating useful knowledge himself, but also advancing the Geological Survey, and contributing to science.

1st. Observe the character of the rocks, if any are exposed in your vicinity, whether they are arranged in layers, (stratified), or occur in irregular masses, (unstratified); whether they contain any curious petrifactions, or shapes of animals or plants in stone.

2d. If there are different beds of rock lying one above another, as sandstone, limestone, &c., note their thickness, extent upon the surface, and order of superposition.

3d. In excavations for railroads, canals, sinking shafts for wells, mining, &c., preserve specimens of the rocks, clays, soils, &c., of every foot in depth, and take careful minutes in writing, of the order in which they occur.

4th. Collect specimens of all rocks, clays, marls, peats, and all soils remarkable either for productiveness or sterility in your vicinity. These should be fair average specimens, and such as would afford, on examination, a test of the composition of the entire mass from which they are taken.

5th. Carefully preserve all petrifactions, and all bones, teeth, tusks, or other remains of animals found in the soils, clays, gravels or elsewhere.

6th. If beds of limestone, fit for marble; grindstone quarries; sand, which might be used for glass, &c.; clay for pottery; metallic ores; or any mineral substance which, in your opinion, might be valuable, occurs, collect and forward specimens of each kind.

7th. Where veins of ore are being worked, (in the "lead region particularly,) notice their length, direction, increase and diminution in thickness, as they traverse the rock, depth below the surface, and product of ore. Accurate drawings of particular veins which can be prepared easily by the practical miner, as he works them out, would be of great value.

8th. Let the owners of all works for the reduction of ores, furnish a statement of the amount of ore worked, cost and method of reduction, and pure metal produced, during the year.

9th. When quarries are being worked for building stone capable of being dressed or polished, let owners of such quarries prepare blocks or slabs, polished or dressed in the best style, and forward them to Madison. Such blocks should be at least 1 foot square and of the thickness of the layer to which they belong. They will be arranged in the cabinet of *Economical* Geology with the name of the owner, and will *represent their* locality for all time to come, in the State *Collection.*

It is of course for the interest of every quarryman to advertise his stone in this manner, and it would be a great public convenience, enabling any one to see at a glance, the building material of our whole State. Accompanying such specimen should be, a statement of the precise location of the quarry, distance from railroad or water transportation, cost of quarrying, and amount of stone accessible. This information will be filed in the cabinet, so that an architect may come to Madison and obtain such information as he needs for public or private purposes.

10. In general, collect all specimens, and facts, which in your opinion will be interesting or useful to be generally known.

Persons residing near locations where interesting petrifactions are attained, may do much for science by a little care. Very good local collections of that kind have been made by Gen. Smith of Mineral Pt., I. A. Lapham, of Milwaukee, E. C. Hobart, City Engineer of Beloit, Henry Woolson, Esq., of Iron Ridge, and T. J. Hale, a talented young naturalist of Racine.

Specimens of rock or ores should be about 4 inches square. Petrifactions should be sent whole, whatever may be their size; if broken in extracting from the rocks, carefully preserve the fragments. Soil, sands. &c., may be put up in four ounce vials. Each specimen should be wrapped in paper by itself with a label, stating its precise locality, written with ink. When thus prepared, specimens may be forwarded in a box carefully packed, to the *State Geologist, Madison, in care of the Governor.* They may be sent by the member elect from each assembly district, who will no doubt see to their safe delivery as a matter of public interest, or forwared by any other means which may be thought proper.

All communications may be directed to E. DANIELS, *State Geologist, Madison*, where they will be sure to reach me at any time.

## NATURAL HISTORY.

The great naturalist, Prof. Louis Agassiz, is now engaged in writing and publishing his work upon the animals of America. Its completeness will, of course, depend upon the unmber of specimens that he may may be able to examine. For several years, many public spirited persons have aided him, by collecting and forwarding specimens of animals.

It is certainly desirable that the animals of our State should have as large a place as possible in that work. New and strange animals are found, from time to time, which are lost, for want of a little care.

Let such persons, as are willing to aid the advancement of science, preserve in spirits, or otherwise, according to the nature of the specimen, everything which seems strange or new. Collect all the fishes of the streams, ponds, or lakes; also, the crawfish and shellfish, as well as, toads, frogs, lizards, turtles, snakes, insects, &c. These can be put into cans, bottles, or kegs, sealed and forwared, labeled with locality, &c., either to me, at Madison, or directly to Prof. Agassiz, at Cambridge, Mass. They will be properly acknowledged, and whatever is new among them will be named and described, in the forthcoming work of Agassiz.

As a matter of public interest, and connected with the Natural History of our State, I call attention to the labors of Dr. Weinland, a highly scientific German, now at Cambridge, and bespeak for him the co-operation of the friends of science. Dr. Weinland is fully endorsed, by Prof. Agassiz, with whom he was formerly associated in Europe, by Dr. A. A. Gould, of Boston, the distinguished Conchologist, Dr. Wyman, and the highest scientific authorities of the world.

I give an extract from his circular, and trust that in a matter of vital importance to the public health, as well as great scientific interest, he will meet the response that he merits:

"I have commenced writing a hand-book on the PARASITES OF MAN, comprehending all the parasitic (intestinal) worms, *insects* and plants (Fungi) that have been found in or on man.

This book is intended for the use of every person who would become acquainted with the interesting history and organization of this group of living beings, so much dreaded by, and yet so dependent upon, mankind.

Our view is this: that only a thorough zoological and physiological knowledge of these parasites can lead to a sound understanding of the pathological phenodomena which they produce in the human body, and, when necessary, to a successful therapeutic treatment.

Thus we shall, for instance, when beginning with the Helminthes, or intestinal worms of man, first give a full account of the nature and organization of Helminthes generally, of their embroyological development, their wanderings from one animal into another, from man into animals, and from animals into man, &c. Then on this theoretical zoological view will naturally be based the practical medical view, aiming at a thorough knowledge of all the different species that have been found in man, of the prophylactic against them, of the pathological symptons that indicate their presence in the human body, and of those remedies that have been proved successful.

One example may show how necessary it is for the practising physician, and for the people generally, to be acquainted with at least some facts of the embroyological development of these worms, viz:

*We know now by experiment that one of the most common tapeworms of man (the Tænia solium), when eaten by a hog, produces in the muscles of the hog the measles (measly pork). We know that these measles contain the larvæ of that tapeworm, and that, if one of them is eaten by man, in an nninjured state, the larva develops itself into a regular tapeworm in the intestine of the man.*

In the same manner the dog gets its tapeworms from the measles, found in the mesentery of the hare and rabbit, the cat, from those found in the liver of rats and mice, etc.

I would most respectfully solicit your assistance, and ask of you to send me specimens of the parasitic worms of man and animals. Any specimens sent to me, even the most common, will be highly acceptable, and thankfully acknowledged in my work. The common earthworms, which are generally considered as one species (Lumbricus terrestris, L.), but of which we have undoubtedly a number of different genera and species in the United States, and the hairworms (Gordius aquaticus, L.), which show an extremely interesting embryological development, are also much needed from the different parts of the country for careful examination. Living specimens would be very valuable. Parisatic worms may be kept alive for several days in the white of an egg, hair worms in water, and earthworms in moist earth. To send them alive is of course possible only in the warm season. Dead specimens can be forwarded in small phials with alcohol of about 60 per cent., or with common whiskey.

Any specimens you may be able to send, please forward by express to Dr. D. F. Weinland, at Prof. L. Agassiz's Zoological Laboratory, Cambridge, Mass.,—labelled concerning the locality or the animals in which they were found. Also other remarks, which you might deem useful, would be gratefully received.

Trusting that my labors will prove worthy of the support of my scientific friends, I subscribe myself,

Respectfully, yours,

David F. Weinland.

Cambridge, Mass., October 27, 1857.

## EXPENSE OF GEOLOGICAL SURVEYS.

As it has been supposed by some persons that our State had made very large expenditures in Geological surveys, with small results, as compared with other States, I give below some facts which will enable every one to judge intelligently upon this point. The three Western States nearest us, who have surveys of this kind in progress, are Missouri, Illinois, and Iowa.

The Geological survey of Missouri was commenced in 1853 with an appropriation of $10,000 per annum, under the superintendence of Prof. Swallow. About $40,000 have been expended, and two very creditable annual reports published. Iowa has an appropriation of $5,000 per annum. The survey hrs been conducted by Messrs Hall and Whitney and has been in progress three years. No report has yet been published, but I understand one will soon appear.

The Geological survey of Illinois has $6,000 per annum. It began in 1852 with $5,000, but has since been increased. Dr. Norwood its able chief has made only reports of progress, but has a large amount of materials for an interesting and valuable final report.

Our own survey was commenced in 1853 with an appropriation of $2500 per annum for four years. Of this appropriation, about $7000 was expended.

The work was interrupted by the death of Dr. Percival and as the appropriation was too small to sustain a creditable survey, it remained suspended during 1856. Last winter the survey was revived with an appropriation of $6,000 per annum for six years. I was entrusted with one department of that survey. Under my contract with the State, I have drawn from the treasury $1,997 91 during the year 1857. This covers all the expenses of my department for that year, including outfit, team, transportation of specimens, fitting up rooms, assistance, together with the cost of analyzing the iron ores, which was necessary in order to determine their value, before the publication of my report.

There has been no other expenditure in this State, for Geological surveys than those here named.

It is but just to allow the Geologist time to mature his results, before finding fault that he has not done more.

In this State we have thus far had constant interruptions and no one has been allowed to carry out to completion any branch of the survey. The utility of such surveys is not at this day to be questioned, after being so abundantly proved by the experience of every important State in the Union, and the united concurrence of the most intelligent nations of Europe.

But that utility can only be developed by hard work and patient study extended over a series of years.

EDWARD DANIELS.

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